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FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

CYCLING TO THE UNIVERSITY:

Evaluating the potential mobility patterns changing towards bicycle

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To my family

Life is like riding a bicycle. In order to keep your balance,
you must keep moving
Albert Einstein

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ABSTRACT

Policymakers at many universities are struggling to promote cycling in the local community in a way to recover campuses as a more livable and sustainable area, as well as decrease the current pollution emissions rate from students and staff commuting patterns. Thus, providing and making bicycles accessible are considered promising initiatives to deliver such issues. However, the effectiveness regarding how it can establish a bicycle culture, in a current car-orientated built environment must be explored, highlighting the role of personal factors and physical conditions on the likelihood to uptake cycling as a commuting mode of transport.

This dissertation applies the Transactional Model of Behavior Change to investigate the influence of bicycle provision on attitudes and perceptions related to cycling to the university, taking the U-Bike Portugal Project and the Faculty of Engineering at the University of Oporto as the study case. The present research uses a mixed method approach, both quantitative and qualitative, which were structured based on the Attitudinal Survey and Cycling Experience assessment.

This research found the new cyclists would maintain such mobility choice under the provision of better bicycle facilities and security. The main deterrents to cycling are the lack of safety, inadequate cycling conditions, heavy road traffic and bad weather, especially for those traveling longer distances.

The provision of the bicycle has the potential to increase self-awareness and better attitudes towards cycling. After the experiencing the use of the bicycle for commuting purpose, more than half of the participants moved to a better stage in the Behavior Change model. However, this research revealed the unattended bicycle access scheme is not determinant to create and maintain such new mobility pattern since barriers as the lack of security, heavy traffic and poor road conditions play an important role on the likelihood of potential new cyclists to keep such modal choice for commuting purposes.

Furthermore, the present research indicates the most favorable target population for U-Bike Project is in the *Preparation* stage, which contains those who have the most positive views and attitudes to maintain such new mode of transport afterwards.

KEYWORDS: *Sustainable University, active mobility, behaviour, change, cycling.*

RESUMO

Planeadores em muitas universidades estão implementando medidas para promover o ciclismo na comunidade local de forma a tornar o pólo mais habitável e sustentável, bem como diminuir a atual taxa de poluição decorrente dos padrões de deslocação de estudantes e funcionários. Desse modo, fornecer ou facilitar o acesso à bicicleta são consideradas iniciativas promissoras para solucionar tais questões. No entanto, a eficácia em termos de como tais medidas podem estabelecer a cultura do uso da bicicleta, como modo de transporte pendular, em um sistema urbano orientado para o automóvel, deve ser explorada.

Esta dissertação aplica o Modelo Transacional de Mudança de Comportamento para investigar a influência da provisão de bicicletas nas alteração de atitudes e percepções relacionadas ao uso do modal na deslocação para a Universidade, com foco no Projecto U-Bike Portugal e a Faculdade de Engenharia da Universidade do Porto como caso de estudo. A presente pesquisa administra uma abordagem metodolófica mista, qualitativa e quantitativa, estruturadas na avaliação dos resultados do Inquérito e do Estudo Prático.

Condições de infraestrutura e segurança devem ser garantidas para que os novos ciclistas mantenham a frequência do uso da bicicleta. As principais barreiras idenficadas foram a falta de segurança, falta de ciclovias e fracas condições de circulação, tráfego intenso e mau tempo, especialmente para aqueles que viajam longas distâncias.

O fornecimento de bicicletas tem o potencial de aumentar a autoconsciência e melhorar as atitudes com relação ao ciclismo. A avaliação do Estudo Prático revelou que após a experiência do uso da bicicleta, mais da metade dos participantes deslocando-se para um estágio mais positivo no Modelo. Entretanto, esta pesquisa revelou que o esquema de acesso à bicicleta não é determinante para manter esse novo padrão de mobilidade, uma vez que barreiras como a falta de segurança, congestionameento e condições precárias de circulação desempenham um papel importante na probablidade de novos ciclistas uutilizarem esse modal para viagens pendulares.

Assim, presente pesquisa indica que a população alvo mais favorável se encontra no estágio de Preparação, que contém aqueles com visões e atitudes mais positivas para manter o uso do referido modo de transporte posteriormente.

PALAVRAS-CHAVE: Universidade sustentável, mobilidade ativa, comportamento, mudança, ciclismo.

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SYMBOLS, ACRONYMS AND ABBREVIATIONS

A – Action stage

AMP – Oporto Metropolitan Area

BAZ – Bicycle Accessibility Zones

BCS – Behaviour Change Stage

BSS – Bike Sharing System

C – Contemplation stage

CDUP – Centro de Desporto da Universidade do Porto

CO2 – Carbon dioxide

COP21 – Paris Climate Conference

EC – European Commission

ECF – European Cyclists' Federation

GCI – Green Campuses Initiatives

GIS – Geographic Information System

IMT – Instituto da Mobilidade e dos Transportes

FEUP – Faculty of Engineering of University of Oporto

FIG. - Figure

LBR – Long-term Bike Rental

M – Maintenance stage

POSEUR – Programa Operacional Sustentabilidade e Eficiência no Uso de Recursos

PPPs - Public Private Partnerships

P – Preparation stage

TDM – Transportation Demand Management

TOE – Tons of oil equivalent

TP – Public transport user

SOV – Single occupant vehicle

SUMP – Sustainable Urban Mobility Plan

PC – Pre-Contemplation stage

UP – University of Porto

1
INTRODUCTION

1.1. SUSTAINABLE MOBILITY

In the last decades, environmental and sustainable issues are highlighted in urban agendas by policy makers and authorities worldwide. In fact, as we move into the 21st century, environmental problems such as land scarcity, high level of motorisation, pollution, greenhouse emissions and the consequent climate change and environmental degradation are a great matter of concern (Poinsatte, 1999). In most of the cases, cities are undergoing a development characterised by the spread of several activities to suburb communities, resulting in a general increase of traveling, and commuting trips by car.

Recently, to deal with such global issues, 195 countries adopted the first-ever universal, legally binding global climate agreement, at the *Paris Climate Conference* COP21, in December 2015. The central aim of this worldwide cooperation is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius. Such deal brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects (European Commission, 2015).

The current EU's agenda emphasises the programming principals based on the *Smart, Sustainable and Inclusive Growth* fields, targeting overcome the structural weaknesses in Europe's economy, improve its competitiveness and productivity and underpin a sustainable social market economy, pursued by Europa 2020 Strategy. Moreover, such plan targets reducing greenhouse gas emissions by *20%* by 2020 and *40%* by 2030.

To reduce the current motorisation level and the dioxide of carbon emissions, the management of sustainable mobility is getting attention within the transport network discussion to improve environmental quality.

European Commission proposed, from its *Action Plan on Urban Mobility*, the tool called *Sustainable Urban Mobility Plan* (SUMP) as a contribution to reach the European climate and energy targets. In contrast to the traditional transport planning approaches, such new concept places emphasis on the involvement of citizens and stakeholders, as well as the coordination of policies between multiple sectors - transport, land use, environment, economic development, social policy, health, safety, energy - within local and national authorities. SUMP is a strategic plan designed to manage the mobility needs of people and businesses in cities and their surroundings for a better quality of life (May, 2016).

Moreover, changing the current mobility paradigms by creating both public transport oriented and car-free development, requires efforts to strengthen the links between land use and transport, by reducing

the need to travel and its distances, and encouraging greater use of public transport (Banister, 2008; Saelens *et al.* 2003). In this matter, the application of SUMPs seems to be very promising to solve such issues, since it builds on existing planning practices and takes into consideration principles as integration, participation, and evaluation (May, 2016).

In such context, the active modes of transportation – cycling and walking – have been encouraged as a shift towards more sustainable modes (May, 2016). Principally throughout *Travel Demand Management* (TDM), investment in public transport and a range of soft measures designed primarily to reduce the use of single occupancy cars (Banister, 2011).

A modal shift to cycling has a clear potential to reduce carbon emission in the transport sector. A study assumed that if the whole EU population would cycle as much as the population of Denmark did in 2000, between 55 and 120 million tons of CO2 could be saved annually by 2020 (Federation, 2017).

However, all forms of transportation have an impact on the environment, either directly or indirectly. In fact, cycling is not a zero emissions mode of transport, and recent research has shown that carbon dioxide emissions because of cycling are approximately 11gCO2/PKT - Passenger Kilometers Travelled. These emissions include the cyclist exhalation and the embodied emissions of the manufacture of the bicycle (Mantonm, 2012). Nonetheless, most studies of environmental impact analysis within transportation have no taken into consideration the net increase in CO2 emission due to increase in respiration and the energy required in cycle manufacture.

Concerning peak times, cycling has the lowest direct emissions per passenger kilometer, while transport by private vehicles is the most energy-intensive transport mode. A study has shown that just a fully occupied average sized private car may compete with public transport services at certain off-peak times. An increase in the fuel efficiency of buses could potentially result in an emission factor equivalent to an active cyclist. For other modes, overall emissions are dependent on passenger occupancy. As occupancy increases, the difference in emissions between modes decreases (Walsh, 2008).

Above all, a swift from fuel-based modes of transportation to sustainable options is desirable since cycling emits far less carbon than driving a car and has great potential to reduce carbon emission in the transport sector.

The implementation of sustainable plans focusing on the active modes of transportation is highlighted worldwide in different scales of action. In the European context, there are exemplary cities which are struggling to increase their cycling usage level, since the typical compact mixed-use development and the current mobility policies generate shorter trips distances, which are better covered by walking and cycling (Pucher *et al*, 2009).

For instance, in Innsbruck, considered the cycling capital of Austria, the bicycle has a great influence on mobility and urban life, with a share of *23%* of all daily trips (Pospischil, 2014). In Copenhagen, almost half of the commuting trips are made by bicycle. Such accomplishment is due to the Danish spatial planning focused on improving the cycling network to foster a healthy public life and a “no need for a car” community, what has decreased the level of automobile motorisation significantly, in the last 50 years(Gehl, 2010). Paris had the urban space dedicated to cars narrowed by approximately a third between 2001 and 2012, with the resulting free space redistributed to cleaner transport modes. Also, urban planners reduced the traffic speeds to 30 km/h in many neighborhoods where investments in green areas were realised (Koning, 2014).

Portuguese authorities, aiming at reducing energy consumption, air pollutants emissions, traffic congestion in cities, and developing awareness around sustainability matter, have set several plans along

the years, such as: *PNAEE*[1] (2013-2016), *CiclAndo*[2] (2013-2020), *Compromisso para o Crescimento Verde*[3] (2015), *U-Bike Portugal* (2016-2020), among others (IMT, 2016). However, despite these sustainable projects and policies, the modal split in the country is still largely motorised, with the number of bicycle users below the European average.[4]

Regarding sustainable actions in local-scale, University campuses are one of the sectors with the great potential to reduce its negative environmental impacts in the urban fabric, by encouraging the increase of the active modes of transportation and reshaping the current mobility patterns of our society. Some researchers showed that creating a green, sustainable and multimodal transportation system in the university campus could make lasting impacts on the travel behavior (Marans, 2012; Poinsatte, 1999; Balsas, 2003). Furthermore, such diverse and plural community makes a significant contribution to the development of our society, and therefore have a special societal responsibility, in particular about the sustainable protection of the environment and the use of resources (Balsas, 2003; Viebahn, 2012).

Such institutions are comparable with a city, regarding consumption of energy and materials and its consequent environmental impacts (Alshuwaikha & Abubakar, 2008). The environmental pollution is an unsettling concern, not only in the lecture halls, research laboratories, and in the administrative are but mainly in the outdoors limits (Viebahn, 2002). Studies found a considerable growth in vehicle traffic, as more people travel from ever-increasing distances to get to campus (Poinsatte, 1999), and the active commuting remains low within students (Kaplan, 2015). Consequently, the high level of motorisation affects not only the campus environment but also, directly the transport network and the entire urban fabric, resulting in an increased pollution level and congestion.

Many universities are implementing sustainable transportation policies and actions, on their current plans, focused on encouraging the bicycle usage in a way to reach a more attractive university environment. Such mode of transportation plays an important role in the increase of the active commuting patterns within the university constituents and the general population. Some studies have shown that making youngers experience cycling as a normal daily means of traveling is the first step towards keeping them on their bicycle in their adult lives (Dufour, 2010; Gatersleben, 2010). Furthermore, since trends in motorisation on college campuses equate those experienced by the whole society, campus transportation initiatives and plans have the power to communicate sustainability, as well as reshape society's transportation patterns (Balsas, 2003).

Following these current sustainable transportation issues and efforts targeting the increase of bicycle modal share and the decrease of CO2 emissions, Portuguese authorities have launched an ambitious national cycling mobility project for the main Portuguese Universities along the country, during fall of

[1] Plano Nacional de Ação para a Eficiência Energética: such plan defines transports as the priority are for further sustainable policies interventions.

[2] Plano Nacional de Promoção da Bicicleta e Outro Modos Suaves: to promote the regular use of bicycle and the adoption of sustainable mobility solutions, associated with the creation of better and safer conditions for reach a behaviour change and attitudes towards soft modes of transportation. The main goal is to encourage the rationalization of the use of private and motorized transportation modes, in particular through the provision of bicycles for public use.

[3] Within Ministry of Environment, Spatial Planning and Energy, which targets measures to promote bicycle usage in the urban mobility.

[4] According to census 2011, travels by foot represented a share of *17,7%* in Portugal, which is higher than the European average, which was around *12,6%*. However, travels by bicycle had an increase from *1%* to *1,6%* between 2007 and 2010, while the European typical rate in this matter was *7,4%*.

2016. Such plan, namely *U-Bike Project*, aims to increase bicycle usage rate within 15 universities, from enabling temporary both conventional and electric bicycles ownerships to students and staff, who are currently relying on motorised modes of transport, with emphasis on car users. The wider purpose of this plan is to promote cycling in the local community, recover campuses as a more livable and sustainable area, as well as decrease the current pollution emissions rate from students and staff commuting patterns. Such sustainable mobility plan is part of the *Program Portugal 2020*, firmed from a partnership between IMT – *Institute of Mobility and Transportation*, and POSEUR – *Operational Program Sustainability and Efficiency Management of Recourses*.

1.2. RESEARCH OBJECTIVES AND STRUCTURE

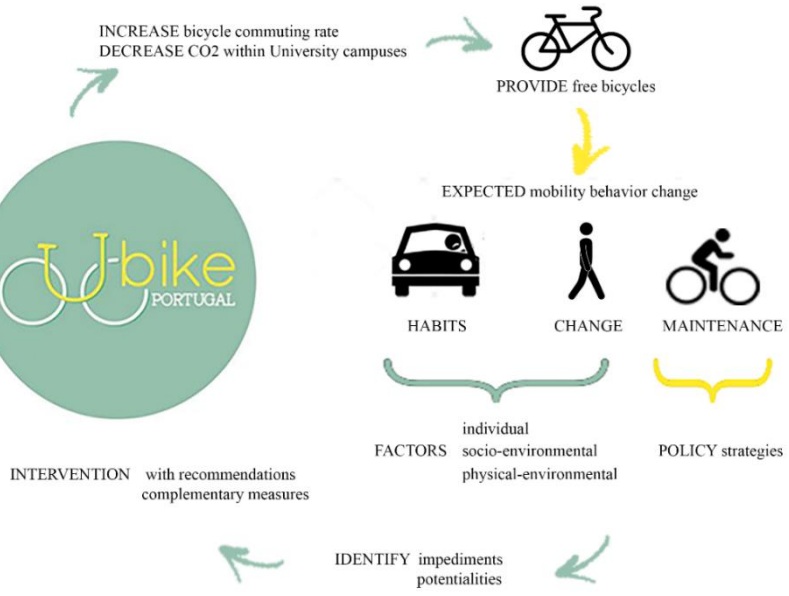
Although the U-Bike Project is intended to promote regular bike usage in the academic community and spread this pattern into the urban fabric, it is unclear, however, the extent to which this specific bicycle provision can generate such modal shift, in a wider context. There is a need for research to identify the effectiveness of this initiative regarding how it will establish a bicycle culture within university campuses, in a current car-orientated built environment. Researching the influence of bicycles provision in the promotion of sustainable mobility amongst students and staff who have been relied on automobiles, could be a valuable source of information to other universities interested in upgrade the overall quality of life on their campus from planning measures that seek to increase commuting cycling mobility by rethinking their current sustainable plans. The main objectives of this research are:

(1) Investigating the current attitudes and perceptions towards cycling amongst the university population;

(2) Examining the potential of the bicycle supply to induce a take up and maintenance of cycling in the university context; and

(3) Exploring the community's needs and barriers towards cycling to assess the favorable target population for the bike renting scheme U-Bike Portugal.

Fig. 1 - Study Case – Flow chart problem



Following this introduction, this document is organized into 5 chapters. The literature review explores in depth concepts associated with the study case issues through four sections. The first chapter (*2.1. Cycling incentives in the University Campus Environment*) starts with an overview of the sustainable mobility initiatives in university campuses, focusing on the importance of sustainable mobility approaches, such as Green Campuses Initiatives and TDM measures, as well as their roles in reshaping the university mobility patterns. Furthermore, give an insight into the extent to which cycling initiatives at the university can succeed and transform the local environmental community, by exploring nine study cases across Europe and USA.

Since this research aims to evaluate the potential of the U-Bike Project within the mobility behaviour change, it is essential to understand the favorable and unfavorable factors related to cycling. Thus, the following section (*2.2 Motivations and Barriers to Cycle to University*), focus on the main deterrents and motivators of cycling highlighted in the literature, considering not only the socio-economic, physical-environmental and the individual factors, but also the current planning strategies,

In a way to understand the impact of bicycle provision on amending sustainable mobility behavior, the third section (2.3. *Bike Access Schemes*) explores the outcomes of two strategies intended to ease the bicycle access, already established in most of the urban networks, namely the Bike- Sharing Scheme and the Long-term Bike Rental.

To investigate the potential of the community to embrace such sustainable mode of transport, the last section (*2.4. Understanding the Target Group – Cyclist Categories*) explores the different methodologies and results regarding target public categorisation into cyclists' profiles. Above all, such literature review provides important theoretical and practical basis for the development of the methodologic tools intended to investigate the potential of such university sustainable plan on encouraging bicycle usage in the local community.

The third chapter, of this document, describes the components of the research method - *Data Collection and Analysis Methods*, which allows for the analysis of attitudes and perceptions amongst students and staff regarding bicycle use intentions and examines in more detail to what extent the U-Bike Project can enhance such sustainable transportation modality. The present research uses a mixed method approach, both quantitative and qualitative, which were structured based on the Attitudinal Survey and Action Study assessment. This dissertation applies the Transactional Model of Behavior Change (Gatersleben and Appleton, 2007) to investigate the influence of bicycle provision on attitudes and perceptions related to cycling to the university, taking U-Bike Portugal Project and the Faculty of Engineering at the University of Oporto as the study case. Since the project under analysis is still in the implementation stage and aims to solve the current mobility issues based on a set of political goals or principles, the analysis methods allow the discussion of the added value of the ex-ante evaluation

The forth chapter presents the application of the methodology and the main findings. Firstly, it explores the survey on the quantitative analysis (*4.1. Attitudes and Perceptions towards cycling*), assessing the current transport modal share, travel behavior, the cycling attitudes, as well as the socio-economic characteristics and various aspects of the daily commute to and from FEUP, amongst students the university population. The next evaluation analysis is a qualitative approach (*4.2. Evaluation of the project's potential*), which is focused on the bicycle provision to induce a take up and maintenance of cycling. The last qualitative analyses (*4.3. Evaluation of the university community's potential*), explores the population needs, barriers and potentialities, by each representative of the Model of Behavior Change, in a way to understand in more detail how more people could be persuaded to cycle to the university and asses the favorable target population for the bicycle rental scheme

The final chapter of this research includes the main conclusions, limitations, and recommendations.

2
LITERATURE REVIEW

2.1. CYCLING INCENTIVES IN THE UNIVERSITY CAMPUS ENVIRONMENT

Portugal is not the first country to invest in a program intended to improve active mobility within higher educational institutions. In fact, throughout *Green Campus Initiatives* (GCI) and *Transport Demand Management* measures (TDM), many campuses over the USA and Europe have attempted to promote equity, social justice, and prosperous economy through the management of resource conservation, waste reduction and efficient transportation system (Balsas, 2003).

The main goal of GCI initiatives is to allow universities to develop their structures with the aim of decreasing its negative impacts and develop positively innovative sustainable actions, from the management of six main factors: renewable energy; energy efficiency; hydro efficiency; transport efficiency; waste management and education (Ribeira, 2017). Throughout TDM, which is a packaging term for a variety of planning strategies that promote the more efficient use of transport resources and improve assess for non-motorized commuters (Bond & Steiner, 2006), the use of alternative means of transport are encouraged (Poinsatte, 1999; Rybarczyk & Gallagher, 2014).

Regarding transport efficiency, many campus planners are putting efforts to shift people from single occupant vehicles (SOV) to a more sustainable mode, by promoting cycling and walking throughout TDM measures, (Balsas, 2003; Bond & Steiner, 2006). Such strategies seek to reduce or mitigate the negative aspects of automobile travel including congestion, air quality, and transportation inequity, as well as reduce campus environmental impacts in the urban fabric. Bond and Steiner (2006) have observed that a combination of *push* and *pull* measures resulted in a substantial modal shift within university campuses. These policies include parking restriction, parking pricing, unlimited-access transit, and transit service improvements.

The literature shows positively some aspects associated with sustainable plans implementation. Besides reducing environmental impacts (Banister, 2008), universities can save costs (Velazquez, 2005; Bond & Steiner, 2006), and increase its image from joint efforts and educational programs (Balsas, 2003; Poinsatte, 1999).

Above all, implementing the sustainable university model is a process of continual improvement through education (Velazquez, 2005; Balsas, 2003; Poinsatte, 1999), training (Marans, 2012), engagement,

organization, assessment, monitoring, policy and planning (Alshuwaikha & Abubakar, 2008), research, design, support and promotion (Pucher, 2010), partnership in incremental steps. Thus, GC initiatives and TDM measures may result in a more attractive university environment and may have strong potential to increase active living for the general population (Rybarczyk & Gallagher, 2014).

Within promotion of active modes of transportation, there are some efforts to improve access to bicycle at universities worldwide, by facilitating ownership or enabling temporary use. Thus, this research explored some initiatives intended to facilitate and encourage bicycle usage found over American and European university campuses, which is summarised in Table 1 below:

Table 1 - Cycling Incentives in Universities

CITY	UNIVERSITY	PLAN	MEASURES	TARGET	AUTHOR
Madrid	Ciudad Universitaria	UNIBICI – Bike and ride scheme	The fourth-generation bicycle system	Students and staff	(Fernández-Heredia, Monzón, & Jara-Días, 2014)
Lausanne	Ecole Polytechnique	Bike-rental scheme	Cycle facilities and equipment: second hand bikes, helmets, lockers, light kits	Students	https://developpement-durable.epfl.ch/bike
Surrey	University of Surrey	Green travel plan	Cycle facilities, cycle lanes, parking, shower and equipment	All university public	(Birgitta Gatersleben K. A., 2007)
Durham	Durham University	Bicycle Users Groups BUG	Forum for cyclists	All university public	https://www.dur.ac.uk/greenspace/travel/bug/
Oxford	Oxford Brooks	Cycle scheme	Bike loan purchase	Students	https://www.brookes.ac.uk/services/hr/cyclescheme/index.html
Ghent	Ghent University	Bike-rental scheme	Four types of bicycle, repair service, parking	Students and Staff	(CIVITAS, 2014)
New York	New York University	Bike-sharing	Free daily bike rental	Students and Staff	https://www.nyu.edu/life/sustainability/get-involved/bike-share.html

Davis	University of California	Bicycle safety and injury prevention program	Bike helmet rental, repair and maintenance services, showers and lockers	All university public	(Françoise Poinsatte, 1999)
Florida	University of Florida	Restrictions on car usage	Parking restriction, parking pricing, unlimited-access transit	All university public	(Bond & Steiner, 2006)

From a general perspective, most of the university sustainable plans target the entire community, with special attention to the student population needs. In fact, such population is more representative in numbers than the other groups in the institution environment. From the cases presented above, most of the universities set plans focusing on bicycle provision, followed by complementary measures such as support and maintenance services, TDM measures, cycle facilities and equipment, among others.

Madrid has established a bicycle hiring system called UNIBICI project for use within *Ciudad universitária*, aimed at complementing the transport network by connecting its main nodal points with the final destinations. In fact, promoting bike-and-ride scheme, or the combined use of bicycle and public transport for one trip has grown considerably over the past decade as part of the search for more sustainable transport solutions (Martens, 2007). The UNIBICI project consists of a public bike system to be used inside the campus, either for internal movements or as the last stage of the access trip, particularly for those arriving by public transport, which is the majority. Above all, it extends the accessibility of public transport modes and offers a new and ideal mode of transport for internal mobility, simultaneously rehabilitating communal space. The system proposed is a fourth generation, completely automatic, public bicycle system (Fernández-Heredia *et al*, 2014).

In Switzerland, there is a bike center at École *Polytechnique Fédérale de Lausanne*, which offers free self-service bike rental for students. This scheme also offers second-hand bikes with light kit and lock, new bikes, helmets, locks, light kits, reflective vest, armbands and bells. Furthermore, the urban network connects the cycling system with the university campus and the city bike-sharing scheme. Also, the university offers to its students and staff members a new concept of material transportation by bicycle, called cargo bikes. Such instruments, which are part of a pilot project within the EPFL Sustainable Campus, offer an alternative for material transport on the campus and can be rented for up to 48 hours without any cost.

Related to the daily commute, many organisations in Britain have introduced green travel plans, under a bigger National Government Initiative, aimed at getting more people on their bikes to commute. For instance, as part of the green travel plan, the *University of Surrey* has increased parking charges and restricted the availability of parking permits to those who live within 2 miles of the University. At the same time, it has provided new cycle facilities such as cycle lanes, cycle parking, showers, as well as new bus routes (Gatersleben., 2007).

Durham University, seeking to make environmental conditions better for those who ride to the campus, created the Durham Bicycle Users Group BUG. Such scheme was set up in 2006 as a forum for cyclists working in Durham City colleges and departments. The university policymakers are currently involved in putting together the improvement of cycle network requested, such as more secure cycle parking. Furthermore, this forum organises events, such as lunch hour, bike rides and bike week events. The DBUG represents the cyclists at the University's Greenspace Advisory Group and in their Green Travel Plan Steering Group.

Another example is *Oxford Brookes University*, which has created a link with local bike retailers within a partnership called *Cyclescheme*. The project is a voucher scheme that works as a bicycle purchase loan service, where students can buy a bicycle for a lower price. The arrangement lasts18 months, which is the duration of the loan and therefore the salary sacrifice. Equipment includes bike accessories and safety items. People must be able to use the bicycle for commuting purposes, to be eligible for this program. Although, weekend journeys and leisure cycling also count within this equation.

At *Ghent University*, the project named *studentENmobiliteit* gives students and staff members the opportunity to rent different types of bicycle, for 3 to 14 months. The rental price depends on the type of bicycle and the duration of the rental period. Moreover, the university offers a maintenance and repair service, bicycle parking, and a stolen-bike recovery system based on information technology. Regarding parking, the city also installed 27 covered mini-garages, for safe parking in high-density neighborhoods (CIVITAS, 2014).

From a North America perspective, The *University of California at Davis* - UCD is a good example of being such a bicycle-friendly school. First, cycling commuting to campus represents more than 60% of all trips, mainly due to their extensive network of bike paths and lanes that travel around campus. Second, most of the students live within a three-mile radius of campus (Poinsatte, 1999). However, the most important reason to reach high levels of ridership is due to the *4 "Es",* which is the motto that defines their bicycle mobility program: enforcement, engineering, education, and encouragement. Within this plan, they guarantee to student's bicycle safety and injury prevention program, bike helmet rental, repair and maintenance services, bike commuter showers and lockers. Furthermore, UCD promotes periodic auction of abandoned and unclaimed bicycle, and recreational and fitness events to promotes bike usage (Poinsatte, 1999).

New York University has its Bike Sharing Scheme (BSS), which offers free daily bike rentals to NYU students, faculty and staff. Its main goal is to make biking a reality for more than 50,000 people. This huge idea was born in 2008, from two undergraduate students who spearheaded an effort to test the viability of a bike sharing program at the University. Such scheme allows student and staff members to check out a bike for same-day use, free of charge. Since its inauguration, in the summer of 2010, the program has grown exponentially. The number of bikes and locations has also expanded from 30 bikes across two locations to 80 bikes across 13 locations.

In 2016, portuguese authorities launched the U-Bike Portugal project, within the promotion of the active modes of transportation, particularly by bicycle. The main objective is to change the current mobility behavior patterns of single occupant vehicles (SOV) towards cycling, as well as, reduce the pollutants emissions in the university setting. This project involves 15 Higher Education Institutions in Portugal, by providing 3234 bicycles: 2096 e-bikes and 1138 conventional bikes for students and staff usage.

2.2. MOTIVATIONS AND BARRIERS TO CYCLING TO THE UNIVERSITY

A substantial amount of research in the fields of transportation, health, and psychology has sought to identify factors influencing the uptake of cycling as a mode of transportation (Pitsiava-Latinopoulou, 2013; Marans, 2012). As well as understand student behaviors and attitudes towards active mode (Kaplan, 2015; Manaugh, 2015; Balsas, 2003; Gatersleben, 2007). Understanding the influence of the built environment (Cervero, 2003), and the role of bicycle facilities provision (Molina-García *et al*, 2015; Barnes, 2005), in a way to identify bicycling barriers and motivators. The Table 2 below summarises the main cycling motivators, and barriers found in the literature review:

Table 2 - Motivations and barriers to cycling

INDICATORS	AUTHORS
MOTIVATIONS	
Fitness	Aslak Fyhri, 2017; Patricia Whannel, 2012; Swiers, 2017; Basford, 2002; Judith Y.T.Wang L.M, 2014
Health	Fernández-Heredia *et al*, 2014; Patricia Whannel, 2012; Judith Y.T.Wang L.M, 2014
Enjoyment	Fernández-Heredia *et al*, 2014; Aslak Fyhri, 2017; Basford, 2002; Judith Y.T.Wang L.M, 2014; Gatersleben, 2007
Economy	Fernández-Heredia *et al*, 2014; Aslak Fyhri, 2017; Molina-García, 2013; Patricia Whannell, 2012; Swiers, 2017; Basford, 2002; Susan Handy, 2011;
Efficiency	Fernández-Heredia et al, 2014
Environmental awareness	Fernández-Heredia *et al*, 2014; Judith Y.T.Wang L.M, 2014
Convenience	Basford, 2002;
Visible bicyclists	Rybarczyk & Gakkagner, 2014
Well-connected bicycle routes	Rybarczyk & Gakkagner, 2014; Eva Heinen, 2010;
Street lighting	Rybarczyk & Gakkagner, 2014; Eva Heinen, 2010;
Educational programs and events	Françoise, 1999; Balsas, 2003
BARRIERS	
Bad weather	Hu, 2015; Fernández-Heredia *et al*. 2014; Aslak Fyhri, 2017; Patrícia Whannell, 2012; Swiers, 2017; Judith Y.T.Wang L.M, 2014, Rybarcyk & Gakkagher, 2014; Eva Heinen, 2010;
Lack of security and perceived danger	Hu,2015; Fernández-Heredia *et al*, 2014; Aslak Fyhri, 2017; Molina-García, 2013; Dijkstra, 2000; Patrícia

	Whannell, 2012; Susan Handy 2011; Dill, 2009; Judith Y.T.Wang L.M, 2014; Kaplan, 2015; Rybarczyk & Gakkagher, 2014; Françoise, 1999; Gatersleben 2007; Eva Heinen, 2010; Ajay Agarwal, 2012; Rietveld, 2004;
Lack of showers	Hu,2015; Patrícia Whannell, 2012; Swiers, 2017;
Poor cycling infrastructure (lanes)	Fernández-Heredia et al,2014; Aslak Fyhri, 2017; Dijkstra,2000; Car,2003; Basford,2002; Kaplan, 2015; Rybarczyk & Gakkagner, 2014; Ajay Agarwal, 2012;
Lack of storage facilities	Patrícia Whannell, 2012; Kaplan 2015; Eva Heinen, 2010;
Lack of comfort	Fernández-Heredia et al, 2014; Eva Heinen, 2010; Ajay Agarwal, 2012;
Travel distance	Hu,2015; Fernández-Heredia et al, 2014; Patrícia Whannell, 2012; Susan Handy, 2011; Françoise, 1999; Eva Heinen, 2010; Ajay Agarwal, 2012
Topography	Fernández-Heredia et al, 2014; Aslak Fyhri, 2017;
Cost of purchasing a bike	Swiers, 2017; Rybarczyk & Gakkagner, 2014;
Physical effort	Eva Heinen, 2010
Negative social environment	Susan Handy, 2011; Kaplan, 2015; Gatersleben, 2007; Eva Heinen, 2010;
Schedule and time constraint	Hu,2015; Kaplan 2015; Ajay Agarwal, 2012; Rietveld, 2004;

According to the literature reviewed, staff and students would bicycle more under provision of safer and well-connected bicycle routes as well as better lighting, and visible bicyclists, which represents a latent demand for bicycle (Heinen, 2010; Rybarczyk & Gallagher, 2014). The aspect of the bike, which people are most positive towards include fitness and health as the greatest motivators for using the bicycle (Fyhri, 2017; Whannell, 2012; Wang, 2014; Fernández-Heredia *et al*, 2014), followed by enjoyment and pleasure (Fyhri, 2017; Gatersleben, 2007). People would bicycle more due to income limitations, or to save money (Fernández-Heredia *et al*, 2014; Molina-García *et al*, 2015; Handy, 2010; Whannell, 2012; Swiers, 2017). Furthermore, people are more able to bicycle since they find such modality convenient (Basford, 2002) and efficient (Fernández-Heredia *et al*, 2014). Educational programs and events could also facilitate bicycle usage (Poinsatte, 1999).

Universal bicycling deterrents include inclement weather (Hu, 2015; Fernández-Heredia *et al*, 2014; Whannell, 2012; Heinen, 2010), reduced bicycle security, crime, and fear about personal safety (Swiers, 2017; Fernández-Heredia *et al*, 2014; Rybarczyk & Gallagher, 2014; Kaplan, 2015; Whannell, 2012). Increasing trip length represented as a greater trip time has an important and significant negative effect on the attractiveness of cycling (Hunt, 2007), as well as the cost of purchasing a bike (Swiers, 2017).

Individual characteristics such as age, gender may play unexpected roles in the length of bicycle commuting travel times. Previous studies have shown that younger students walked more than older students did. Low socioeconomic status students walked more than those in the high group did.

However, biking was significantly higher in the high socioeconomic status group than the medium group (Shafizadeh, 1997). Students who lived in university residences had significantly higher energy expenditure in both walking and biking than those living in private homes. Walking and biking energy expenditure means were significantly higher when students lived until 2km from university compared with those who lived more than 5km (Molina-García *et al*., 2013).

However, some studies have shown that active commuting remains low for students. Only those students, who live on campus, walk as a principal mode of transportation to classes. Kaplan (2015) has investigated the reasons behind the decision not to walk or bicycle among students and found that pressures of time, the discomfort of weather conditions, busy street, safety concerns and lack of places to park their bikes inhibit active commuting (Kaplan, 2015).

Furthermore, the level of bicycle use is dependent upon the availability of various facilities and services such as: bike paths and lanes (Manaugh, 2015), proper signage, bike parking, and level of cooperation between the school and the town or city in which it is located (Kaplan, 2015; Poinsatte, 1999).

While some studies have shown the importance of facilities to support bicycle commuting, such as showers (Hu, 2015; Swiers, 2017) and secure storage for bicycles (Kaplan, 2015; Whannell, 2012; Heinen, 2010), these actions will have a limited effect if the cycling environment is unsafe between the student's residence and the university.

In the case of campuses transportation management, simply stating a policy goal to increase sustainable commuting may not be sufficient to change travel behavior. Commuters who rely on private automobiles may not fully understand the unsustainable impacts of the car and may not be able to evaluate the actual or perceived barriers and potentialities of public transportation, bicycle, and others sustainable travel modes. Non-motorized traveling can only be maximised by thoroughly integrating bicycling and walking needs and desirable circulation patterns in all transportation, housing, and environmental policies, from a synergetic sustainable plan (Balsas, 2003).

Furthermore, it is common to have a significant conflict between pedestrians and cyclists in the campus environment. Thus, signs and bike paths and lanes are essential for a successful bicycle plan implementation. A student will be more likely to uptake bicycling as a means of transportation if they know the routes and that they will receive guidance if they need it (Poinsatte, 1999). Since transportation is the link between student life and the community, offering greater choices for mobility and accessibility can contribute to a more quality educational experience. When planners consider a package of synergetic measures, cycle emerges as a much more significant mode and has an appreciable impact on car share (Wardman, 2007).

2.3. BIKE ACCESS SCHEMES

The number of initiatives to increase the bicycles access is growing quickly over the past decade as part of the search for more sustainable transport solutions, not only within university campuses but also in many society sectors (DeMaio, 2009). Several different kinds of programs aim to accomplish such goal, either through facilitating ownership or through enabling the temporary bicycle usage. Since this very research aims to understand the benefits associated with the bicycle instruments provision, specifically bike rental schemes within university campuses, this topic will explore two different examples of such supplying. The first one is the *Bike Sharing Scheme* - BSS, which is short-term bicycle access. The second one is the *Long-term Bike Rental Scheme* - LBR, which allows people to access a bike for weeks

or even months. Both modalities provide an environmentally friendly form of transportation as part of the public transport system (Midgley, 2009).

BSS is a short-term bicycle access scheme, which targets daily mobility and allows users to access public bicycles at unattended bike stations, around the city. Commonly concentrated in urban settings, this program also provides multiple bike station locations that enable users to pick up and return bicycles to different stations (Shaheen, 2010). Such scheme is growing vastly, throughout the world, since bike-sharing systems can foster a cycling culture in cities where cycling was previously a curiosity or leisure activity. In 2011 was estimated 375 bike sharing schemes around the world, operating in 33 countries (Midgley, 2011; CIVITAS, 2014).

The literature stressed the following potential BBS benefits, which include: 1) increased mobility options within transportation network; 2) cost savings from modal shifts; 3) lower congestion; 4) reduced traffic congestion; 5) reduced fuel use; 6) increased use of public transit and alternative modes; 7) increased health benefits; and 8) greater environmental awareness. (Shaheen, 2010; DeMaio, 2009; Midgley, 2009).

For a successful BBS introduction, it is also important to highlight key structural conditions: strong commitment to sustainable urban mobility and promotion of cycling; a minimum standard of bicycle infrastructure for safe and convenient cycling; sufficient resources to achieve a real impact; and sufficient space for racks/parking to guarantee access to bicycles (Midgley, 2009). Thus, BBS has the potential to play an important role in bridging the gap in the existing transportation networks, as well as encouraging individuals to use multiple transportation modes, although such program or policy may have different impacts on bicycling in different contexts (Shaheen, 2010; Pucher, 2010)

From Mobility Management perspective, BSS has had profound effects on creating a larger cycling population, increasing transit use, decreasing greenhouse gases, and improving public health (DeMaio, 2009). Furthermore, some studies suggest that this instrument may be a good strategy for increasing transportation cycling for females (Molina-García *et al*, 2015).

Since the BBS establishment, various models of provision have been created and placed from different backgrounds, included government, quasi-governmental transport agencies, universities, non-profits, advertising companies, and for-profits (DeMaio, 2009).

The university model, which can be represented by both BBS and LBR schemes, had the educational institution providing the service, most likely in a campus setting. The benefit of this model is the university can expand its intra-campus transit service without relying on the jurisdiction to offer sufficient bike-sharing service on campus (DeMaio, 2009). For instance, there are over 65 college/university schemes operating throughout North America and another ten programs planned in 2010 (Shaheen, 2010).

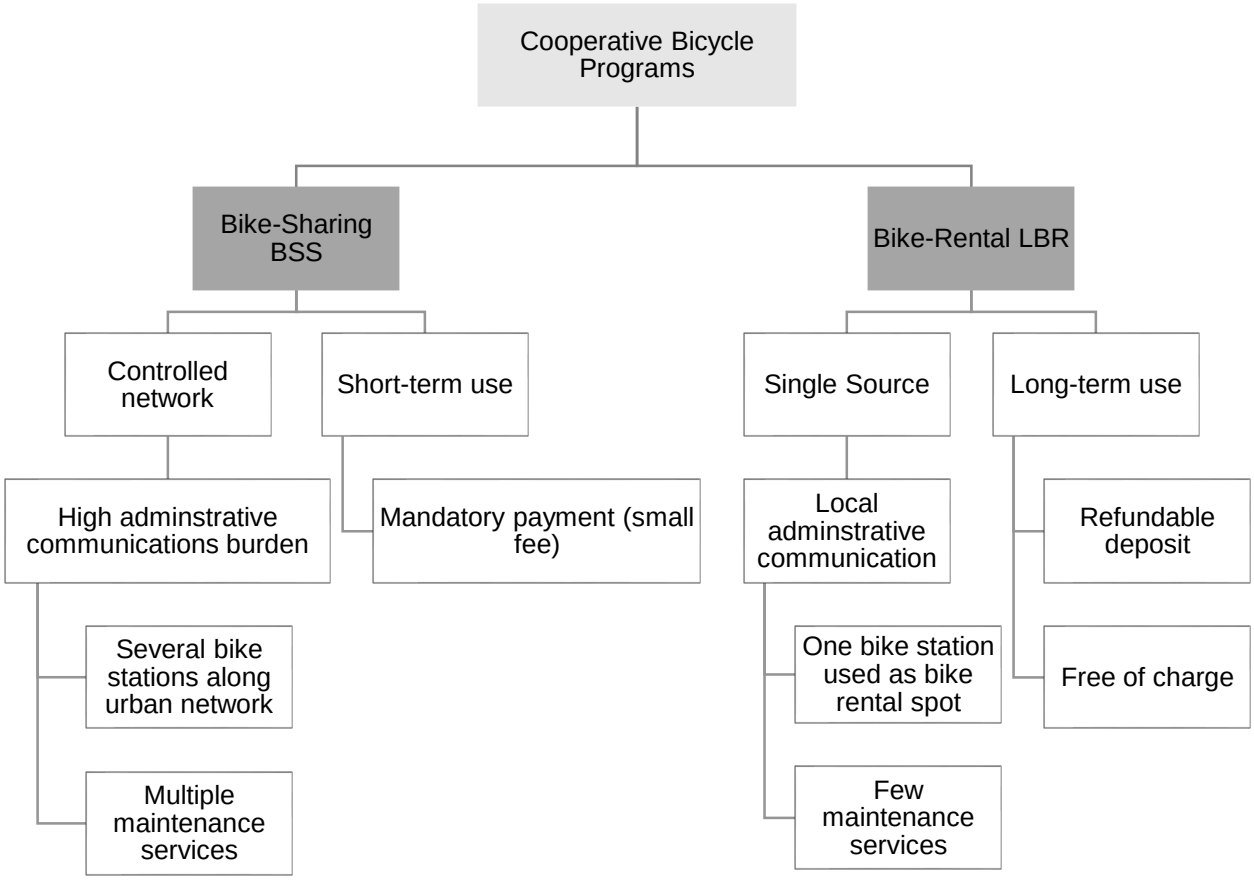
The LBR model is a long-term bike rental that allows people to have access to a bike for weeks or even months. Such scheme is getting attention within university mobility plans since campuses are ideal locations to implement bicycle-lending programs. Such model provides bicycles for students and staff without any charge or, in most of the cases for a refundable deposit (Balsas, 2003).

About the bicycle itself, the classification is according to its functionality and design as the conventional one (human-sourced energy) or e-bike[5] and pedelecs[6] (electric-sourced energy). Some studies have shown the e-bike as a very promising tool for modal transitions in countries with low bicycle mode shares, as this instrument could reduce some barrier effects, such as big distances and hilly topography (Fyhri, 2017). Furthermore, e-bikes seem to be a good option for those living too far away from work to walk or cycle with the conventional bike (Berntsen, 2017).

Both schemes BBS and LBR have the potential to provide different tools to promote a greater culture of bicycling, from facilitating access to the bicycle, as well as, access to bike racks and maintenance facilities. However, safe and comfortable infrastructure is also required to broaden its potential, as well as effective political support (DeMaio, 2009; Midgley, 2009).

The Fig. 2 below illustrates the main differences between these two kinds of cooperative bicycle programs provision, according to the literature reviewed:

Fig. 2 – Characterization of the Cooperative Bicycle Programs



[5] Also known as electric bicycle, power bike and booster bike. It is a bicycle with an integrated electric motor which can be used for propulsion. E-bikes use rechargeable batteries and can travel up to 25 to 32 km/h.

[6] A pedelec (from pedal electric cycle) is a bicycle where the rider's pedalling is assisted by a small electric motor. Unlike some e-bikes, pedelecs are classified as conventional bicycles in many countries by road authorities. Pedelecs can travel up to 25 km/j.

2.4. UNDERSTANDING THE TARGET GROUP – CYCLIST PROFILES

In a way to understand predictors of cycling and develop successful interventions for potential targets groups, some researchers state the hypothesis that there are different types of cyclists, with specific habits and behaviors, regarding different types of facilities, treatments, and environments. From the literature reviewed, categorising cyclists may be useful to understand human perceptions and needs, as a way to increase the efficacy of intervention plans and demonstrate why investment in bicycle facilities are worthwhile. Thus, stakeholders can define target groups for further policies, and understand who would like to cycle, and in which circumstances more people could be persuaded to cycle more.

Table 3 below summarises the main objectives, methodologies, and findings regarding cyclists' categorisation found in the literature reviewed:

Table 3 Cyclists Categorization overview from the literature

AUTHOR	OBJECTIVES	METHODS	CATEGORIES	FINDINGS
(Wang, 2014)	Understand the current bicycle modal share / identify the motivators to cycle / identify factors influencing the route choice	Web-based survey	**1 Cyclists** **2 Infrequent cyclists** **3 Potential cyclists** **4 Non-cyclists**	Cycling is popular among students; improve health and fitness are the main motivators; lack of safety and bad weather are the main barriers
(Dill,2006)	Examine the relationship between the community and environmental factors and people's decision to cycling	Survey	**1 Regular year-round** **2 Irregular cyclists** **3 Non-cyclists**	Younger adults are more likely to be regular cyclists; the neighborhood affects the level of cycling
(Dill., 2013)	Examine a typology developed by the city of Portland	Survey sample based upon the level of comfort on cycling	**1 Strong and the fearless** **2 Enthused and Confident** **3 Interested but Concerned** **4 No way no how**	Enthused and confident adults are most likely to have cycled to school as a child
(Gatersleben, 2010)	Explore what views cyclists and non-cyclists may hold about typical bicyclists and how	Survey	**1 Responsible** **2 Lifestyle** **3 Commuter**	Respondents are more likely to cycle if they see typical cyclists as a day-to-

	such views are related to bicycle behavior and intentions		**4 Day-to-day**	day and commuter cyclists'
(Gatersleben and Appleton ., 2007)	Examine the views of commuters in different stages of change	Survey / action study/ diary report/ interviews	**1 Maintenance** **2 Action** **3 Preparation** **4 Contemplation** **5 Pre-contemplation**	Cycling is more popular among men than women. Those who have never commute by bike were the least positive group
(Heinen, 2010)	Analyze the influence of attitudinal factors on bicycle commuting over different distances	A web-based survey among a sample of employees	**1 Cyclists** **2 Non-cyclists** **3 Full-time cyclists** **4 Part-time cyclists**	Time, comfort and flexibility benefits affect the choice decision. Who commute over longer distances have a more positive attitude
(Winters, 2011)	Determine which elements might be the most likely to influence cycling	Survey sample focusing on cyclists and those contemplating	**1 Potential cyclists** **2 Occasional cyclists** **3 Frequent cyclists** **4 Regular cyclists**	Environment awareness, security and enjoyment are the main motivators. Traffic, ice and snow are the top barriers
(Bergstroom, 2003)	Examine the attitudes towards cycling during winter	On site interviews, hidden observations	**1 Winter cyclists** **2 Summer only cyclist** **3 Infrequent cyclists** **4 Never cyclists**	Road condition, weather, temperature, were more important to women than men.
(Manaugh, 2015)	Understand the physical and psychological barriers associated with the current frequency of cycling	The survey, the multimodal logistic regression model	**1 Never** **2 Rarely** **3 Usual** **4 Always**	potential cyclists are affected by physical barriers. The cycle paths, safety, and secure parking facilities play a significant role in the cycling frequency

Various attributes related to cycling and personal characteristics have been shown to have significant influences on attitudes to non-recreational cycle use, including the type of cycling facility and length of time spent on it, the availability of showers and secure parking at the destination, cyclist age, levels of experience and comfort cycling in mixed traffic and cycle purchase price. Regarding such issues, Wang *et al* (2014) used a web-based survey approach to investigate cycling preferences and the influences of various factors on cycling behavior. The main objective was assessing the current bicycle modal share level, as well as identify the motivators to cycle and factors influencing the route choice. Four categories classified the respondents: *cyclists*; *infrequent cyclists* – who own a bicycle but do not commute by bike; *potential cyclists*- who do not own a bicycle but are interested in cycling; and *non-cyclists.* Although cyclists and the other groups have different priorities regarding their wishes, both groups consider that improvement in safety and provision of a cycleway separated from traffic are the greatest motivators to cycle. In particular, both groups prefer routes with less traffic, lower speed limit, away from traffic noise and air pollution (Wang *et al*, 2014).

Dill (2006) presents a bicyclists categorisation based on a methodologic survey intended to examine the relationship between community environmental factors and people's decision to bicycle. Addressing issues like the frequency of cycling in different seasons of the year, collecting data regarding origin, destination, types of facilities, trip purpose, and trip length, perceptions of neighborhood environment, and demographic questions. This research presents three groups of cyclists: *non-cyclists*; *irregular cyclists* - respondents who rode in the past summer, but not in non-summer months; *regular year-round cyclists* - respondents who rode year-round, including once a week or more in summer. Such research has found that younger adults and men were more likely to be regular and utilitarian cyclists. Respondents who lived in neighborhoods with higher street connectivity were more likely to ride for utilitarian purposes. Furthermore, people who lived in households with other adults that cycled regularly had co-workers who cycled to work, or who saw adults cycling on their street frequently were more likely to be regular cyclists (Dill, 2006).

The city of Portland developed four categories of cyclists based on personal attitudes towards bicycle, as well as the respondent's stated level of comfort cycling on a variety of facility types: *strong and the fearless, enthused and confident, interested but concerned,* no *way no how*. The first one – *strong and the fearless* - will ride regardless of roadway conditions and take a strong part of their identity from riding a bicycle. The second one – *enthused and confident* - are comfortable riding on a road with automobiles but prefer to do so operating in their facilities and appreciate efforts made to in prove bikeway infrastructure. The third group – *interested but concerned* - is curious about bicycling but are afraid to do so and therefore do not regularly ride. The last group – *no way, no how* - will not going to ride a bicycle for reasons of topography, inability, or simply a complete and utter lack of interest. The city of Portland targeted the *interested but concerned* group as the market necessary to achieve ambitious mode shift targets. The first step of the categorisation process using the survey sample considered series of questions about the level of comfort cycling on various types of streets. For each hypothetical scenario, the respondents had to indicate their level of comfort on a scale of one to four. This research found that the enthused and confident adults were most likely to have frequently cycled to school as a child. Furthermore, time constraints and lack of security are important barriers among this group (Dill, 2013).

Gatersleben (2010) explored what views cyclists and non-cyclists in England may hold about the typical bicyclists and how such views are related to bicycle behavior and intention. To reach the typical bicyclist behavior, motivators and its characteristics, four different bicyclists' stereotypes were distinguished: *responsible* - who use a bicycle safely and responsibly; *lifestyle* - keen bicyclist who spend time and money on bicycling; *commuter* - professionals who use the bike to commute to work; and *day-to-day* -

kind, normal people who use their bike for day-to-day activities. This research shows that there is a strong relationship between past cycling behavior and intentions to cycle. Independent of this relationship, respondents are more likely to say that they intended to cycle in the future if they are more likely to see the typical cyclist as a day-to-day cyclist and a commuter cyclist. The perceptions of the stereotypes appeared to vary between respondents depending on how much they used a bicycle and for what reason (Gatersleben, 2010).

Bergstrom and Magnusson (2003) have examined the attitudes towards cycling during winter and about winter maintenances to understand how to increase winter cycling. From on-site interviews and hidden observations with video recording, the research divided respondents according to their stated choice mode for their journey to work, in summer and winter. The categories of cyclists are: *winter cyclist* - a person who uses a bicycle for travelling to work in at least two cases out of five during winter; *summer-only cyclist* - a person who uses a bicycle for travelling to work in at least two cases out of five during summer, but less than two cases out of five during winter; *infrequent cyclist* - a person who cycles fewer than two cases out five when traveling to work, no matter the season; *never cyclist* - a person who never uses a bicycle for a journey to work. In both surveys, the respondents were asked to grade certain factors in order of importance for their choice mode during the journey to work. Winter cyclists valued exercise, cost and environmental aspects as the most important factors. For others, travel time, precipitation, and temperature were more important factors. Summer-only cyclists valued temperature, precipitation, and road condition.

Heinen (2010) analysed the influence of commuter's attitudes toward the benefits perceived, during the cycling commute journey. This research found differences in attitudes between four categories, *cyclists* and, *non-cyclists*, and between *full-time* and *part-time cyclists*. The influence of attitudinal factors on bicycle commuting over different distances assumes that attitudes become more positive and play a more prominent role as the frequency and distance of cycling increase. Therefore, thi study analysed the effect of attitudes on bicycle commuting for three distance groups: short distances of less than 5km, medium distances between 5 and 10 km, and long distances of 10km and more. On average, respondents hold positive beliefs on cycling to work but are negative regarding status, time-saving, and level of comfort. Over every distance class, people are more likely to cycle if they perceive the activity is possible, but the subjective norm only influences the decision to commute by bicycle over short distances. Over long distances, cycling is largely a decision based on individual considerations, not considering other opinions. The more beneficial individuals perceive bicycle regarding time savings, comfort and flexibility and the more importance they simultaneously attach to these benefits, the more often they are commuter cyclists. The attitude awareness is important in the decision on journeys up to 5km and indicates that individuals who consider cycling environmentally friendly, healthy and mentally relaxing are more inclined to cycle to work. To a large extent, individuals base their mode choice decision on the direct benefits regarding time, comfort and flexibility. Individuals who commute over longer distances have, on average a more positive attitude towards cycling than those who cycle shorter distances (Heinen, 2010).

Winters *et al* (2011) evaluated motivators and deterrents of cycling among current and potential cyclists throgout a telephone interview and a self-administered survey. The follow-up survey asked about the preference for bicycle routes types and potential motivators and deterrents of cycling. According to the cycling patterns and motivators, this research categorised the population into four groups: *potential cyclists* - who had not cycled in the previous year but had access to a bicycle and would consider cycling in the future; *occasional cyclists* - who cycled at least yearly; *frequent cyclists* - who cycled at least monthly; and *regular cyclists* - who cycled at least once a week. The top motivators found were: routes away from traffic noise and pollution; routes with beautiful scenery; and routes separated from traffic.

The top deterrents were: ice and snow; streets with much traffic; streets with glass; streets with high-speed traffic; and risk from motorists (Winters *et al*, 2011).

To understand the current low level of cycling and how more people would cycle often or daily, Gatersleben and Appleton (2007) addressed the individual level by examining the views of commuters in different stages of change. This study model categorized the respondents into one of the five categories or stages of change: *precontemplation* - who had never used a bicycle to travel to work and had never considered using one; *contemplation* – who had never used a bicycle to travel to work but had considered using one; *preparation* – who rarely or sometimes used a bicycle to travel to work and that they rarely, sometimes or often considered using one., *action* - who often used a bicycle to travel to work; and *maintenance* – who always used their bicycle to travel to and from work. Regarding the analysis methods applied, such research delivered a survey study and an action study amongst university staff and students. The first study aimed at investigating the attitudes and perceptions of people in different stages of change. The second examines in more detail how more people might be persuaded to cycle. Such study found that cycling seems more common among men than women. Respondents who had never contemplated cycling had the least positive attitude towards cycling, becoming a great target public for further policies (Gatersleben and Appleton, 2007).

Likewise, another research drawn attention to the latent demand for cycling, among a large sample of commuters is Montreal, Canada, to reach a better understanding of the barriers experienced by those who wish to engage in active modes of transportation. The motivations behind such study assessed what physical and psychological factors might influence a person to move along a continuum from a "non-cyclist" to a regular commuting cyclist, and the factors that could be related to a change in cycling frequency, and how public policy could be appropriately orientated to affect a mode shift. (Manaugh, 2015). Firstly, data were collected using a survey targeting students, faculty, and staff. In addition to socio-economic information – age, sex, work or student status, household structure and income – and details of current travel patterns. Respondents were also asked to rate the barriers they faced for the mode that they were least likely to use again. Afterwards, respondents were asked to place a pin on an online map to represent their home location as well as the building on campus where they spend most of their time. Such method allowed for the calculation of the shortest network distance, elevation change, distance to cycling facilities, and presence of dedicated cycling infrastructure along the route to campus. Such study model presents four categories of cyclists, based on their cycling frequency: *never* - who have never cycled from their current home location to campus; *rarely* - who have cycled at least once in the past year, but most often commute by other modes, *usual* - who cycle as a main mode during warm and dry periods and *always* – who cycle the year-round (Manaugh, 2015).

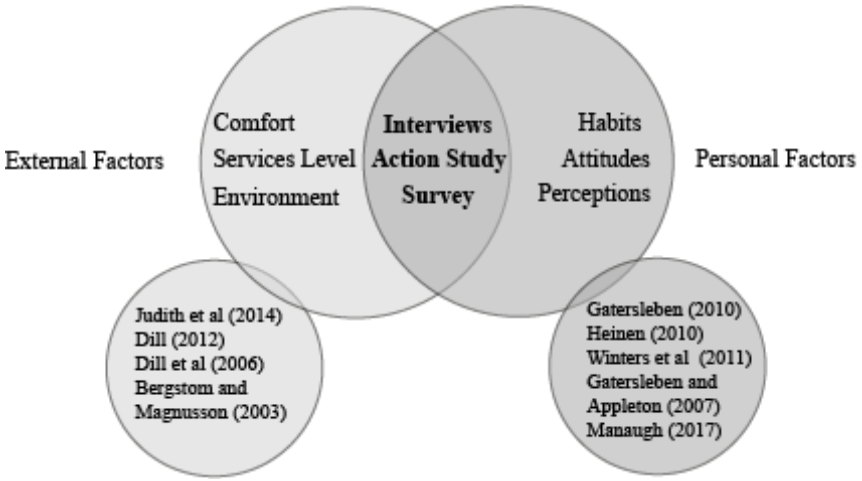
Such research conducted a mixed-methods analysis, to understand and quantify the effects of socio-demographic factors, route characteristics, and residential choice factors on the likelihood of falling into one of the four categories. After that, the research team has focused on the "potential" cyclists - *never* or *rarely* - and their expressed reasons for not cycling more often. Also, respondents evaluated the importance of elements that have been found to discourage cycling: distance, effort, comfort, safety, cost, and presence of bicycle parking. The variables age and most common mode use stratified the findings. Such research has shown that potential cyclists are affected by a complex array of barriers, and revealed the importance of cycle paths, safety, and secure parking facilities (Manaugh, 2015).

Based on the literature reviewed, the cyclist's categorisation methodological tools fall into two spheres – see Fig. 3 -one based on external factors, and another on personal ones. In the former, the built environment, comfort, and services on the current bicycle modal share level play an important role during the cyclist's categorisation process. In the later, personal intentions such as habits, attitudes and

perceptions. In both cases, the literature stressed the importance of interviews, action study, and surveys to gather further information.

Many studies on cycling attitudes compare the views and frequency of cyclists and non-cyclists based on the influence of external factors. However, level of cycling and the propensity to change mobility patterns also can vary, based on personal perceptions. According to Gatersleben and Appleton (2007), a person in attempting to change a behavior typically moves through stages of change, several times. Thus, understand where people in the target audience are in the stages of behavior model is fundamental to develop more effective strategies to make people continue with such new attitude.

Fig. 3 - Cyclist's categorisation approaches



3
DATA COLLETION AND ANALYSIS METHODS

According to the literature reviewed, researches applied various methods to assess barriers and motivators towards cycling to reach a clear understanding of personal behaviours and attitudes. The analysis tools include longitudinal analysis and cross sectional studies (Molina-García *et al*, 2013; Winters, 2011); interviews and attitudinal survey (Gatersleben and Appleton, 2007); real-time observation of bicycling and walking activity in key points (Kaplan, 2015); examination of the infrastructure which can facilitate or imped non-motorized transportation (Kaplan, 2015). The mentioned qualitative approaches are a very valuable source of information since they concentrate on the types of people who would be most likely to provide a spectrum of opinions relevant to the subject. Whereas, the quantitative methods reviewed included baseline questionnaire survey to assess aspects of the daily commute (Gatersleben and Appleton, 2007); geographic information system with longitudinal-latitudinal coordinates of trip origins and destinations (Cervero, 2003); attitudinal surveys designed to gauge cycling and walking barriers and motivators among staff and students to better understand potentialities (Rybarczyk & Gallagher, 2014).

Since the project under analysis is still in the implementation stage and aims to solve the current mobility issues based on a set of political goals or principles, the analysis methods of this dissertation integrate an Ex-ante Project's evaluation focusing on the population, which will be covered by such measures. The assessment of the needs brings a better understanding of the community attitudes towards cycling, as well as its potential to embrace such mobility option. Thus, the present research uses a mixed method approach to answer the following goals and questions of this dissertation, which are:

(1) Investigating the current attitudes and perceptions towards cycling amongst the university population;

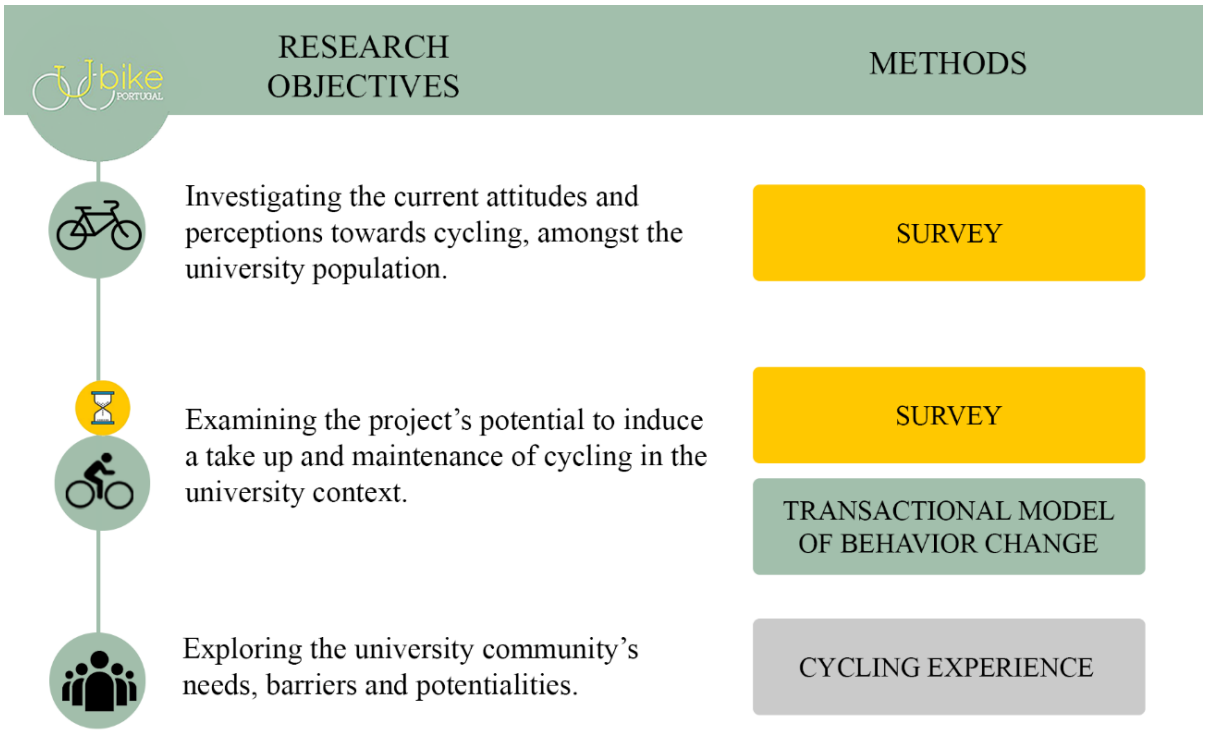
(2) Examining the potential of the bicycle supply to induce a take up and maintenance of cycling in the university context;

(3) Exploring the community's needs and barriers towards cycling to assess the favorable target population for the bike renting scheme U-Bike Portugal.

Furthermore, this approach also clarifies the following secondary issues: (4) The extent to which the current Oporto built environment and the University setting constrain a possible cycling level increase; (5) Within the university community, who cycles and how more people could be persuaded to cycle; (6) For what reasons, students and staff would continue cycling or not, after the U-Bike Project implementation.

The described approach is structured based on three methodological tools: The Attitudinal Survey; The Transactional Model of Behavior Change (Gatersleben and Appleton, 2007; Prochaska, 1994)and the Cycling Experience Study, illustrated in the Fig. 4 below:

Fig. 4 Research objectives and Methods



The first analysis – *Attitudes and Perceptions towards cycling* - is a quantitative approach which assesses the current transport modal share, travel behavior, the cycling attitudes, as well as the socio-economic characteristics and various aspects of the daily commute to and from FEUP, amongst students the university population.

The second approach – *Evaluation of the Project's Potential* - examines the potential of the bicycle supply to induce a take up and maintenances of cycling. According to the survey results, respondents were categorised into one of the 5 Behavior Change Stages (BCS) towards bicycle use, based on the Transactional Model of Behavior Change (Gatersleben and Appleton, 2007; Prochaska, 1994). Thus it was possible to assess the socio-caracteristics, attitutes, barriers and motiviations towards cycling in different stages of change.

The last study – *Evaluation of the University community's Potential* - explores the population needs, barriers and potentialities, by each BCS representative, in a way to understand in more detail how more people could be persuaded to cycle to the university and asses the favorable target population for the bicycle rental scheme. A one-week cycling experience conducted such qualitative study, based on the research method by Gatersleben and Appleton (2007). The following assessments may confirm the hypothesis that each cyclist profile has different perceptions of such cycling experience, which could represent a valuable source of information for further planning and intervention measures.

The following subsections of this chapter describe in detail the structure and objectives of the methodological tools applied in this research.

3.1. ATTITUDINAL SURVEY

To explore the current mobility patterns, cycling attitudes and perceptions in the university, as well as frequency, distance and time spent between the major origins and destinations, this research delivered the Attitudinal Survey to the local community via web service. Such document was conducted as self-administrated questionnaire, where respondents completed it by themselves, between the days of 10th to 30th April 2018. Simultaneously, the respondents were assessed in person and randomly at the faculty setting, to increase diversity and responses rate.

The survey, based on Gatersleben and Appleton (2007), had a short easy-to-follow design in a way to be answered within 5 minutes', and organised in three sections: (1) Home-FEUP Journey; (2) The Bicycle Use; (3) Socioeconomic Profile.

The first section explored questions regarding the commuting journey to and from the university, such as the main mode of transport chosen, and time spent between origin and destination. Furthermore, through a set of five-level Likert items[7], respondents specify their level of agreement or disagreement for a series of 6 subjective perceptions of their current travel and transport mode: (1) Stressful; (2) Fun; (3) Boring, (4) Relaxing; (6) Interesting; (7) Depressive. A set of five-level Likert questions[8] explored the likelihood to use different modes of transport where respondents specify their propensity or not to change their current mobility choice towards the following options: (1) Walking; (2) Bus; (3) Car; (4) Carpooling.; (5) Bicycle; (6) Train; (7) Tram.

The second section assessed the respondent's attitudes towards cycling, by exploring if the respondents own and know how to ride the bicycle, their bicycle's usage frequency to different activities, and how many cyclists, for commuting purposes, they already know. Furthermore, intentions and perceptions towards the bicycle were measured through 12 five-level Likert statements, where respondents specify their level of agreement or disagreement.

The last survey section explores the respondent's socioeconomic profile, followed by the assessment of the respondent's intention to participate in the cycling trial study.

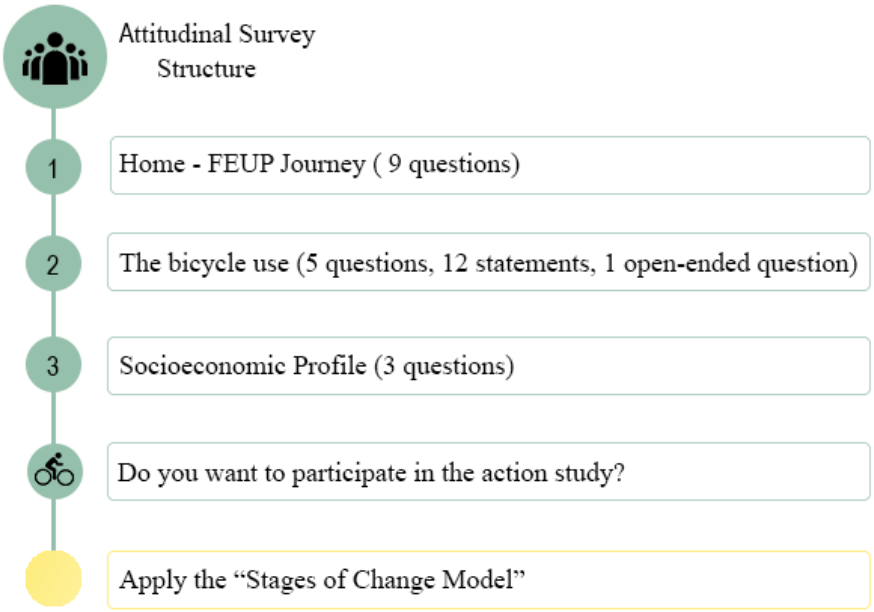
The survey also counted with an open-ended question, asking under what circumstances the respondents would be willing to cycle to the university, more often. Such question was essential to analyse the Transactional Model of Behavior Change, presented in the next subsection.

Such survey had a response rate of *5%*, with 505 participants within FEUP community. This sample excluded 8 respondents due to the lack of address information. The Fig. 5 below illustrates the attitudinal survey structure, with the respective sections and number of questions. The entire survey is attached in the appendix, at the end of this document.

[7] The format of the five-level Likert item used was: 1. Strongly disagree, 2. Disagree, 3. Agree, 4. Strongly agree, 5. No Opinion

[8] The format of the five-level Likert item used was: 1. Very Unlikely; 2. Unlikely; 3. Perhaps; 4. Quite Likely; 5. Very Likely

Fig. 5 - Attitudinal Survey Structure



3.2. TRANSACTIONAL MODEL OF BEHAVIOR CHANGE

To examine in more detail, the project's potential to induce and maintain a take up to cycling, it is important to reach a better understanding of the community attitudes towards cycling. According to Gatersleben and Appleton (2007), a person in attempting to change a behavior typically moves through stages of change, several times. Thus, understanding where people in the target audience are regarding the stages of behavior change is fundamental to develop more effective strategies to make people continue with such new attitude. The five Behavior Change Stages (BCS) are – *Precontemplation, Contemplation, Preparation, Action,* and *Maintenance.*

This research categorised the respondents based on two survey variables: (1) how often they used a bicycle to travel to the university and (2) based on the respondent's intention to use a bicycle for commuting purposes in the future. The Table 4 below presents the characteristics of each one of the five BCS groups:

Table 4 - Behavior Change Stages based on Gatersleben and Appleton (2007)

STAGE	CHARACTERISTICS
Precontemplation	Never used a bicycle to travel to the university and considered very unlikely using one in the future.
Contemplation	Never used a bicycle to travel to work, and considered unlikely, perhaps and quite likely using one in the future.

Preparation	Rarely or sometimes used a bicycle to travel to the university, and considered unlikely, perhaps, quite likely and very likely using one in the future.
Action	Often used a bicycle to travel to university.
Maintenance	Always used a bicycle to travel to and from the university.

After assessing who cycles and who does not, the next step of this approach was to investigate what motivates these different groups. To study the extent to which respondents can be moved closer to action, the survey asked under what circumstances they would be willing to cycle to the university more often (Gatersleben and Appleton, 2007).

3.3. CYCLING EXPERIENCE

The last study approach aimed to explore in more detail which group, of the 5 BCS, would be the most favorable one in terms of Target Population within U-Bike Project and to understand how more people could be persuaded to cycle and maintain such mobility behavior To accomplish such objectives, this research developed a one-week cycling experiment based on the research method by Gatersleben and Appleton (2007).

Among the 78 people interested in participating in the proposed action study, 34 bicycle owners were contacted in a way to gather and select people to participate in the Study. After sorting the volunteers, based on the BCS representatives, this study selected ten volunteers: three in the *Maintenance* stage; two in the *Action* stage; two in the *Preparation* stage; and three in the *Contemplation* stage. There were none volunteers from *Precontemplation* stage. In fact, such profile is considered the most difficult group to embrace such mode of transportation.

By means of personal variety, such sample gets at least one representative person from each university community groups. Between the people interested, it was selected: 2 professors; 2 researchers; 5 master's students; and 1 PhD student. None representative people from Non-teaching staff and Degree's students have demonstrated an interest in participating in such study. In fact, such groups are less representative in numbers within this survey, if compared with the whole sample. Regarding gender variety, the final study counted with a share of *70%* of men, and *30%* of women. By means of nationality, the interest was higher within foreigner than local people, with a share of *60%* - 1 Spanish and 5 Brazilian volunteers.

This study divided the cycling experience into two stages. The first one from 14th to 18th May 2018, with six volunteers, and the last one from 21th to 25th May 2018, with four volunteers, to enlarge the environmental perceptions, variables, and conditions within the analysis. The meteorological conditions were favorable in those weeks, counting with just one rainy and cold day. In the other days, the temperature remained steady between 16ºC to 23ºC degree.

For one week, the participants had to evaluate their commuting journey into a self-completion *Travel Diary* delivered to them during the first interview. In such document, they were asked to describe the most pleasant and unpleasant experience during their cycling journey to and from the Faculty in a daily schedule, as well as report the route chosen, and the time spent between the origins and destinations. A color scale scheme analysis gathered the experiences from the *Travel Diary*, with *green* representing the

perception in a positive a way, and *red* in a negative way. Furthermore, the cyclists' perceptions were organised into four factors, based on the literature reviewed (Fernández-Heredia *et al*, 2014):

(1) *Trip*: journey duration, speed, and flexibility.

(2) *Environmental*: topography, weather, pollution, and traffic.

(3) *Structure*: ground pavement, urban form, unsafe parking, and narrow routes.

(4) *Subjective*: perception of risk, exercise opportunity, drivers' hostility, and fatigue.

This research conducted interviews with the volunteers before and after the one-week period, as a way to assess their perceptions changing, such as expectations and worries regarding cycling to the university. In the first interview, respondents were asked how they usually traveled to the university and why, as well as why they wanted to participate in the study and their expectation about the cycling trial. In the second interview, they were asked about how they had experienced the study and whether and for what reasons they intended to continue cycling or not, as well as what they had enjoyed most and what they had enjoyed least (Gatersleben and Appleton, 2007).

3.4. STUDY CASE

This research is structured into an Ex-ante Project's evaluation, focusing on the academic community at the Faculty of Engineering at the University of Porto, which will be covered by the sustainable mobility project U-Bike Portugal, which is currently in the implementation stage.

3.4.1. OPORTO

Oporto city, the second largest city in Portugal, stretches across 4166km^2 and is home to 263000 inhabitants, configuring a polycentric urban structure with a high concentration of jobs in the central city, but is experiencing a process of population and employment decentralisation towards surrounding municipalities. Thus, as people have in recent years increasingly moved from the centre to the suburbs, new mobility patterns have emerged, which are characterised by longer trips and urban sprawl, which caused serious congestion problems (Silva, 2014).

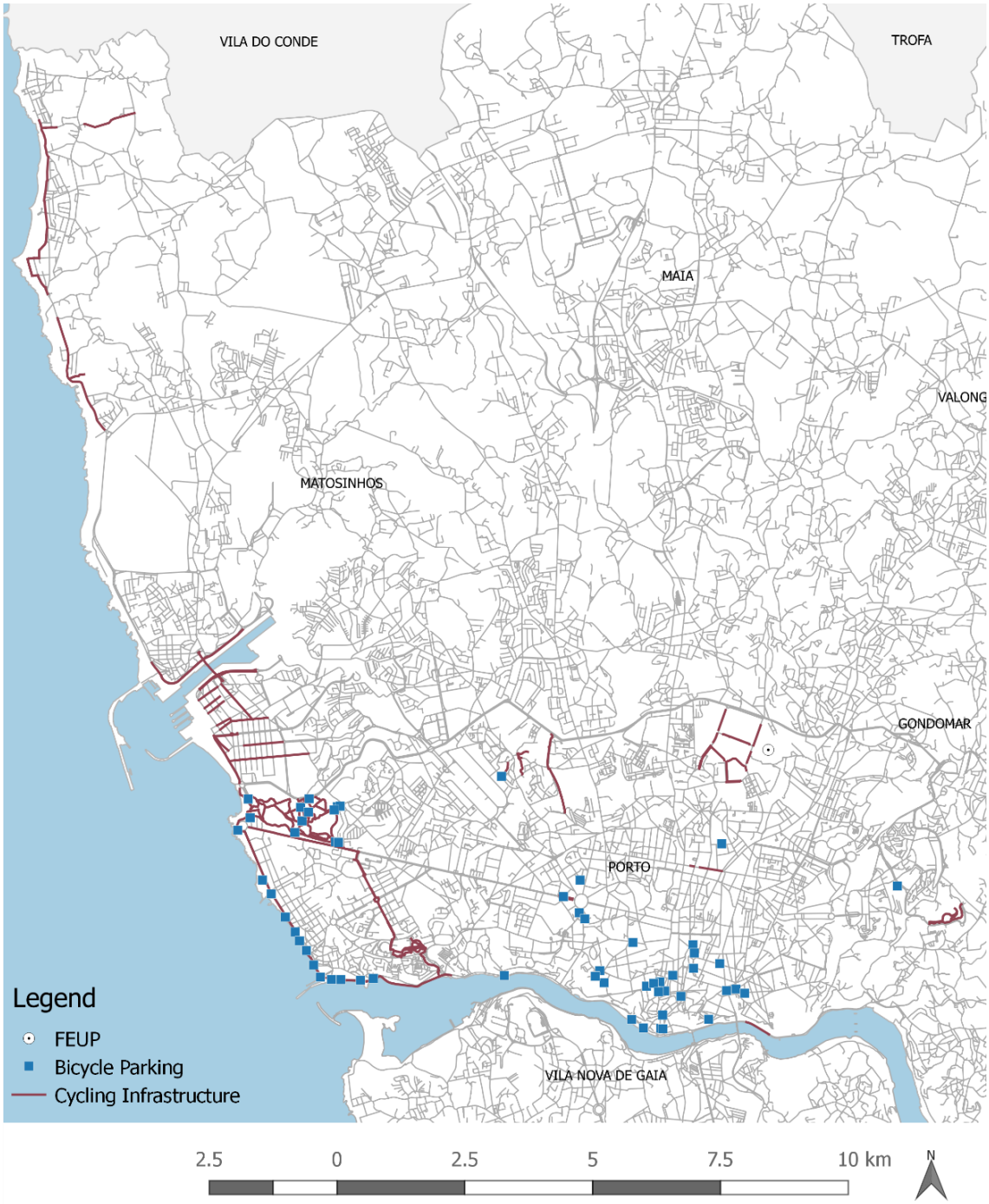
The automobile is the first-choice mode of transport with a share of *43%.*, while the modal share for public transport is *25%* and *32%* for walking. In the past, transport policy primarily focused on the extension of road capacity but is now increasingly concerned with the improvement of the public transport system, especially through the metro system (CIVITAS, 2012).

Regarding active mobility patterns, according to census 2011, travels by foot represented a share of *17,7%* in Portugal, which is higher than the European average, which was around *12,6%*. However, travels by bicycle had an increase from *1%* to *1,6%* between 2007 and 2010, while the typical European rate in this matter was *7,4%*. Furthermore, the European Bicycle market and Industry Profile (2016)[9] sold 360000 bicycles and 1000 e-bikes in Portugal. Such rate is not considered an expressive number if compared with another European country, like the Netherlands, which has sold around 988000 bicycles, 276000 of these are e-bikes.

[9] Data collected from ecf.com/cycling-data on 27th March 2018.

From data base collection, the Map 1 identifies the current cycling infrastructure and bicycle parking spots in two municipalities in the great Oporto: Porto and Matosinhos. Such facilities location and numbers could influence the current low active modal share level since the cycling network has a great deficit of connectivity and directness.

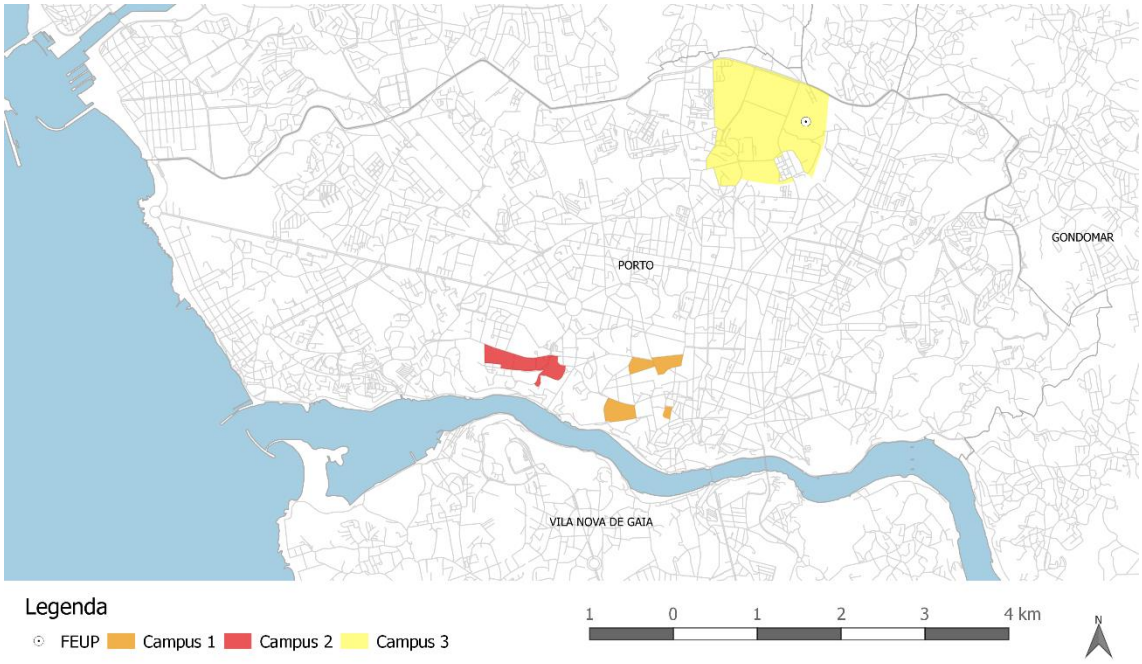
Map 1 - Cycling facilities in Oporto and Matosinhos



3.4.2 FACULTY OF ENGINEERING OF UNIVERSITY OF OPORTO

Altogether, Porto is home to 60,000 university-level students, with 35762 people from UP community, one of the largest academic institution in the country, with three campuses meeting such population demand: *Campus1* located in the downtown; *Campus 2* in Campo Alegre area, near to Douro river and *Campus 3* Asprela, located in the north area of Oporto city - Map 2. This dissertation explored in depth the Faculty of Engineering FEUP – Map 3 - located in the Campus 3. Such zone concentrates one of the highest numbers of students[10] and is characterised by severe mobility problems, such as illegal parking and congestions in critical dimensions, despite a good public transport in the quarter (Eugénio, 2012)

Map 2 - Campus Location



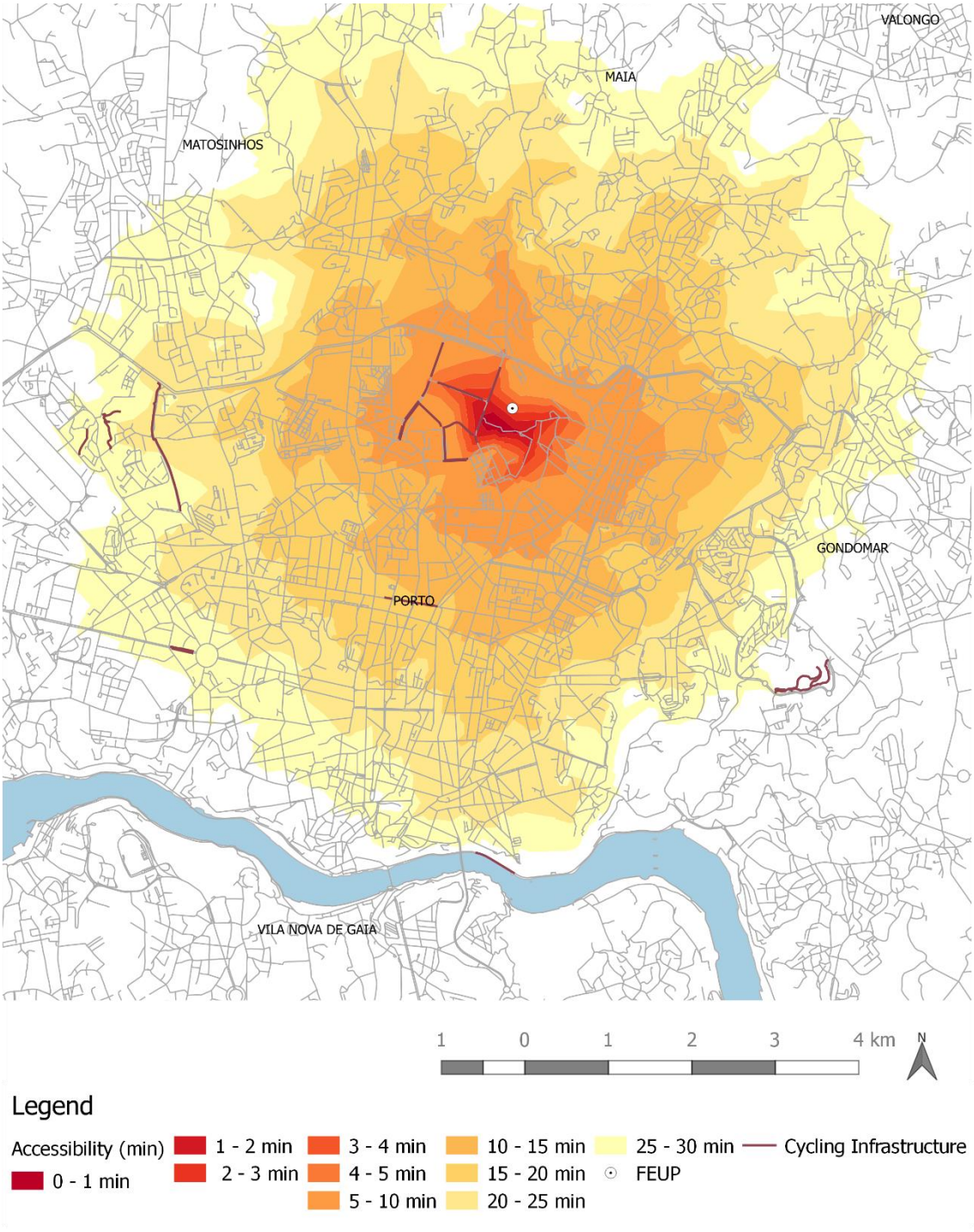
Taking into consideration the following variables - Topography, Road Hierarchy and Cycling infrastructure - within the current land-use and transport network, it was created the bicycle accessibility zones (BAZs) surrounding FEUP. Such zones illustrate the distance in minutes to access the focal point – FEUP, based on the so-called differentiated speed for bicycle DBS[11].

[10] According to data collected from 2016-2017 term, there are 7924 students enrolled at FEUP.

[11] To calibrate the urban network based on the local *Topography*, it was considered that with the increase of slope, there is a decrease of cyclist's speed. Regarding *Road Hierarchy*, each road was numbered according to the following criteria: Motorway (1), Trunk (2), Primary (3), Secondary (4), Tertiary (5), Residential and Living street (7). In this research, motorway and trunk were not considered into the calculation, since such categories do not allow cyclists circulation. Furthermore, with the increase of the criteria, also increase the bicycle accessibility conditions. Regarding the *Cycling Infrastructure*, the urban network was also measured according to the presence or not of cycle lane or cycle path. The absence of cycling facilities decreased the accessibility levels.

The BAZs was conducted using GIS, from the establishment of time buffers based on the DSB along the network, in a way to understand the influence of the built environment on the current cycling rate, as well as to measure the accessibility conditions between the campus and the community origins,

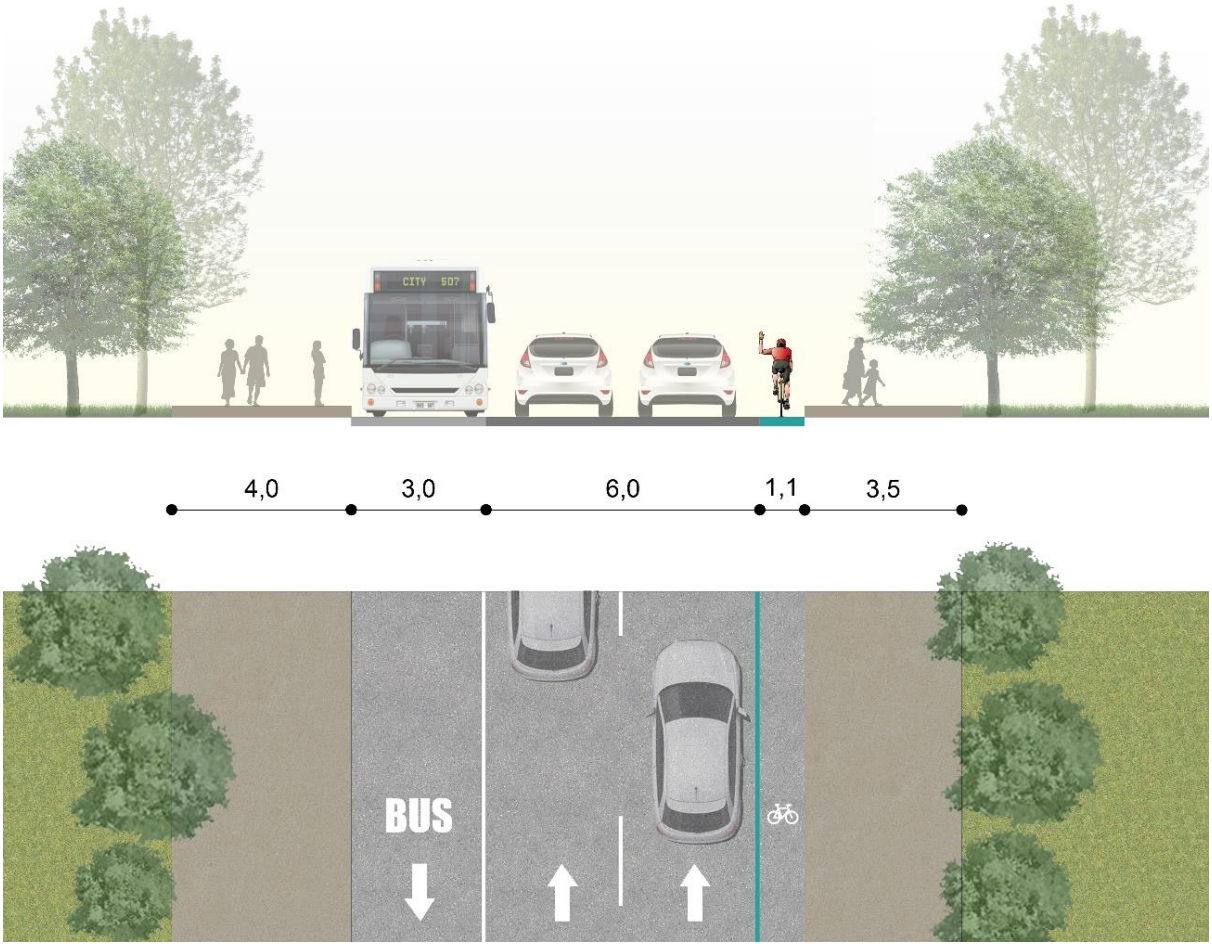
Map 3 - FEUP accessibility conditions and Cycling Infrastructure



gathered in the survey. Such buffers were set within several time frames: firstly, between 1-1-minute distance until reach 5 minutes, then between 5 to 5 minutes, until a maximum of 30 minutes' distance.

Throughout the accessibility conditions surrounded FEUP it is noticeable that the lack of cycling infrastructure and the road hierarchy play a crucial role in the current low accessibility cycling level. Furthermore, the surrounding cycle lanes do not offer greater accessibility, since its design do not offer the minimum security-dimensions required for a secondary road, as represented in the Fig. 6 below:

Fig. 6 - Road profile near FEUP



The space available for cyclists represents a share of *6,25%*, while the motorised area occupies a share of *51%*, making visible the planning priorities towards the vehciles, which affect the performance of bicycle circulation. In fact, the necessary space for cyclist's movement varies in function of the road hierarchy and slope. Beyond the vital space of circulation, the urban design guidelines recommend an additional space for security purposes, which guarantee a safer distance to fixed objects when traveling, such as curbs, parked cars, urban furniture, vegetation, among others (IMT, 2011). Thus, IMT cycling network guidelines suggested a minimum room for cyclist's maneuverer, illustrated in the Fig. 7

Furthermore, a photographic database was developed to give more emphasis to the cycling infrastructure conditions in the campus – See Fig. 8. Such data collection[12] illustrates the current bicycle paths and lanes, street pavement, parking spots for bicycles and sidewalks in the university setting.

Fig. 7 - Minimum dimensions for cyclist's circulation, in secondary roads, according to IMT

Fig. 8 - Current bicycle facilities (cycle paths and parking spots) in the University campus

[12] Data collection delivered during June 2018.

3.4.3 U-BIKE PROJECT

U-Bike Portugal is a national project intended to promote soft mobility patterns focusing on increasing the bicycle usage, particularly by providing e-bikes and conventional bicycles to students and staff of selected higher education institutions. The IMT coordinates such sustainable project, while the associated Universities develop and implement it. Furthermore, such initiative is aligned with *Portugal 2020*[13] programming, and supported by PO SEUR[14] (IMT, 2016).

In the year 2016, PO SEUR approved the plan implementation within 15 Higher Education Institutions around the country. In total, will be purchased 3.234 bicycles (2096 e-bikes and 1138 conventional ones), to be delivered to the academic community. The initial goal is the adherent population will ride more than 2.412.141 kilometres, and consequently generate savings around 166,34 Tons of oil equivalent TOE, in detriment of the use of individual modes of transportation, by the end of the year of 2018 (IMT, 2015).

From a National level point of view, the project coordination is carried out by IMT, which establishes guidelines mainly around the following topics: (1) Promotion; (2) Complementary Measures; and (3) Monitoring system.

IMT will perform, systematically, a set of *Promotion actions* intended to increase the target public awareness around the project, as well as the entire community, recurring to the main communication platforms such as the internet, social media sources, newsletters, flyers, brochures, information sessions, and periodic meetings.

Regarding the *Complementary measures*, IMT intends to complement the plan promotion in both local and national level, taking in consideration less systematic forms of communication such as clarification proceedings, events, seminars, forums, technical articles publications, dissemination of good practices, workshops, media partners, and publicity. These actions must also consider measures that can contribute to the mobility improvement in the university campus.

The National Scale sphere outlined the *Monitoring system* indicators and requirements, to gather results uniformly. Such set of indicators will serve as a basis for the evaluation operations, which allows the analysis of comparative evolution, according to the objectives outlined and observed progress.

Within the University of Porto, the project is coordinated by CDUP[15], which is responsible for delivery and manage the contracts for the temporary bicycles use. According to the management model established, the bicycle distribution will follow the subsequent quotation: *70%* for students, *10%* for teachers and researchers, *10%* for non-teaching staff and *10%* for scholarship holders. Furthermore, such bicycle provision shall consider the following criteria order:

(1) Availability of free bicycles at the Campus where the user studies or works;

(2) Commitment by the user to change the way he or she travel to UP, using the bicycle as the main sustainable means of transport;

[13] Partnership agreement between Portugal and the European Commission, which brings together the five European Structural and Investment Funds in a way to define principles to set out the economic, social and territorial development policy between 2014 and 2020.

[14] Programa Operacional Sustentabilidade e Eficiência no Uso de Recursos

[15] Centro de Desporto da Universidade do Porto

(3) Commitment by the user to use the bicycle periodically, traveling a minimum distance of 10 kilometres per day in a period of 6 to 12 months;

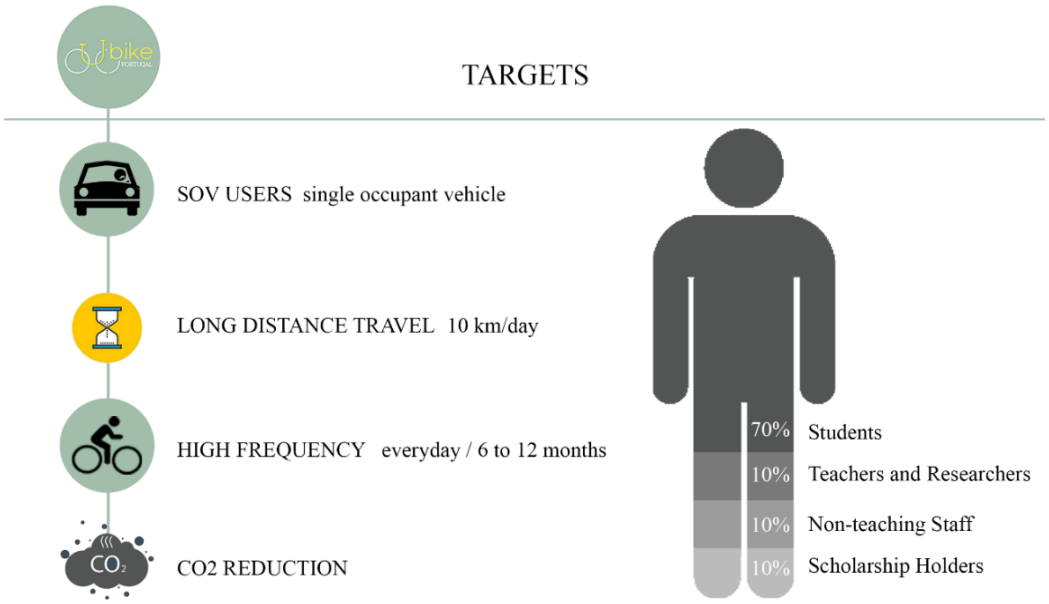
(4) Higher probability of CO2 reduction or other pollutants emissions.

When the adherents receive the bicycle, they will also receive a kit, which includes manual/project brochure, network map, helmet, repair material, safety locks and reflective material. Within 3 months, the adherent must take the bicycle to the repair place for maintenances purposes, on a scheduled basis. At the end of each contract, the coordinators will evaluate the possibility of its renewal, always favouring a system of user's rotation. The University of Porto (UP) is expected to provide 45 conventional bikes and 220 e-bikes within such sustainable mobility project at the beginning of the 2018-2019 term.

As observed within the literature reviewed, the Monitoring system solution and Evaluation are essential for a sustainable plan implementation, which should include selected indicators, collecting data sources, analysing data, presenting results and evaluating the development process (May, 2016). The management system, within U-Bike project at UP is supposed to offer the following minimum indicators, focusing on environmental aspects: (1) Number of bike uses per day by user type; (2) Location; (3) CO2 emissions; (4) Calories produced and consumed; (5) Average time and speed of movement; and (5) Elevation gains.

CDUP has established the following 8 achievement and outcome indicators, in order to evaluate the project along the time: (1) Energy savings, calculated from the modal swift from automobiles to bicycles, based on the estimated Km travelled; (2) Σ E-bikes and conventional bikes, 60% might be reserved for SOV users; (3) User's km travelled; (4) Promotion campaigns and actions, including flyer, poster, brochure, news/press releases and video; (5) Population covered by promotion campaigns and actions, which expect the involvement of 94050 people; (6) Primary energy savings achieved by the modal shift; (7) Target population degree of adherence towards bicycle use; (8) Target population degree of adherence towards promotions campaigns and actions. The Fig. 9 below illustrates the main U-Bike project targets:

Fig. 9 - U-Bike Project's Targets

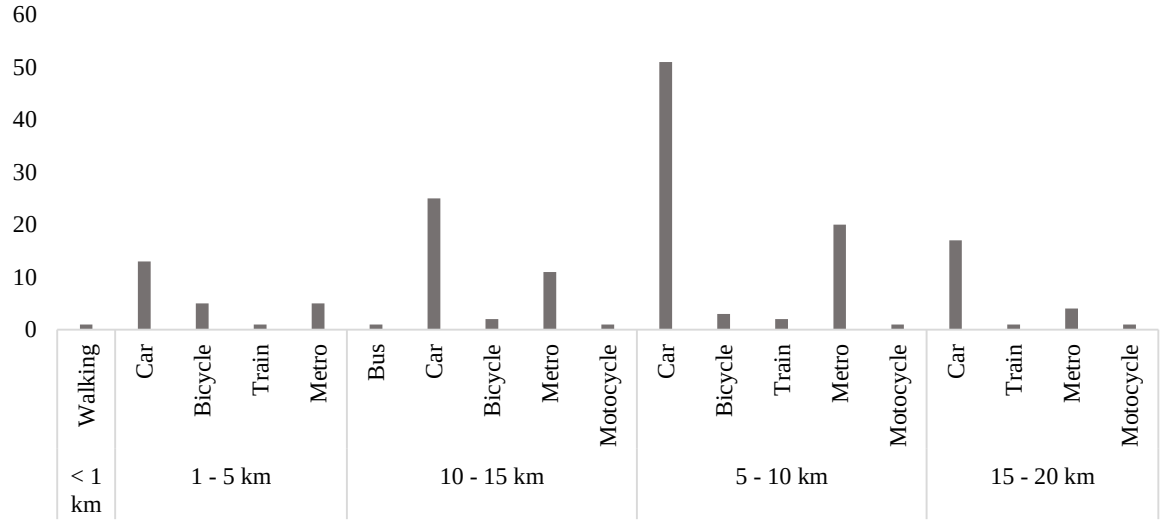


During the year of 2017, CDUP launched two surveys to the university community within U-Bike Project. The first one was intended to gather the current academic mobility patterns data and collect information about to what extent, students and staff would be interested in embrace such initiative. The second one was intended to collect applications from those interested in participating in the project, followed by the selection of those who meet the criteria to receive the requested bicycle.

The first survey had 340 responses - *58%* men and *42%* women. From such sample, 129 people are FEUP representatives, counting with 54 SOV users, 21 bus users, 18 tram/metro users, 26 pedestrians and 7 currently cyclists – see Chart 1.

By analysing the transport mode preferences within commuting distance, the car usage is higher than the active modes - cycling and walking - in all travel distances gathered, excluding those who travel less than 1 km to reach the pole. Car usage level is considerably higher within 5 – 10 km, while public transportation usage remains at a medium rate. Among all the distances, the bicycle was used more often within 1-5 km, and not considered as a commute option from 15km journey distance.

Chart 1 - Distance and chosen transport mode (Journey Home-FEUP)

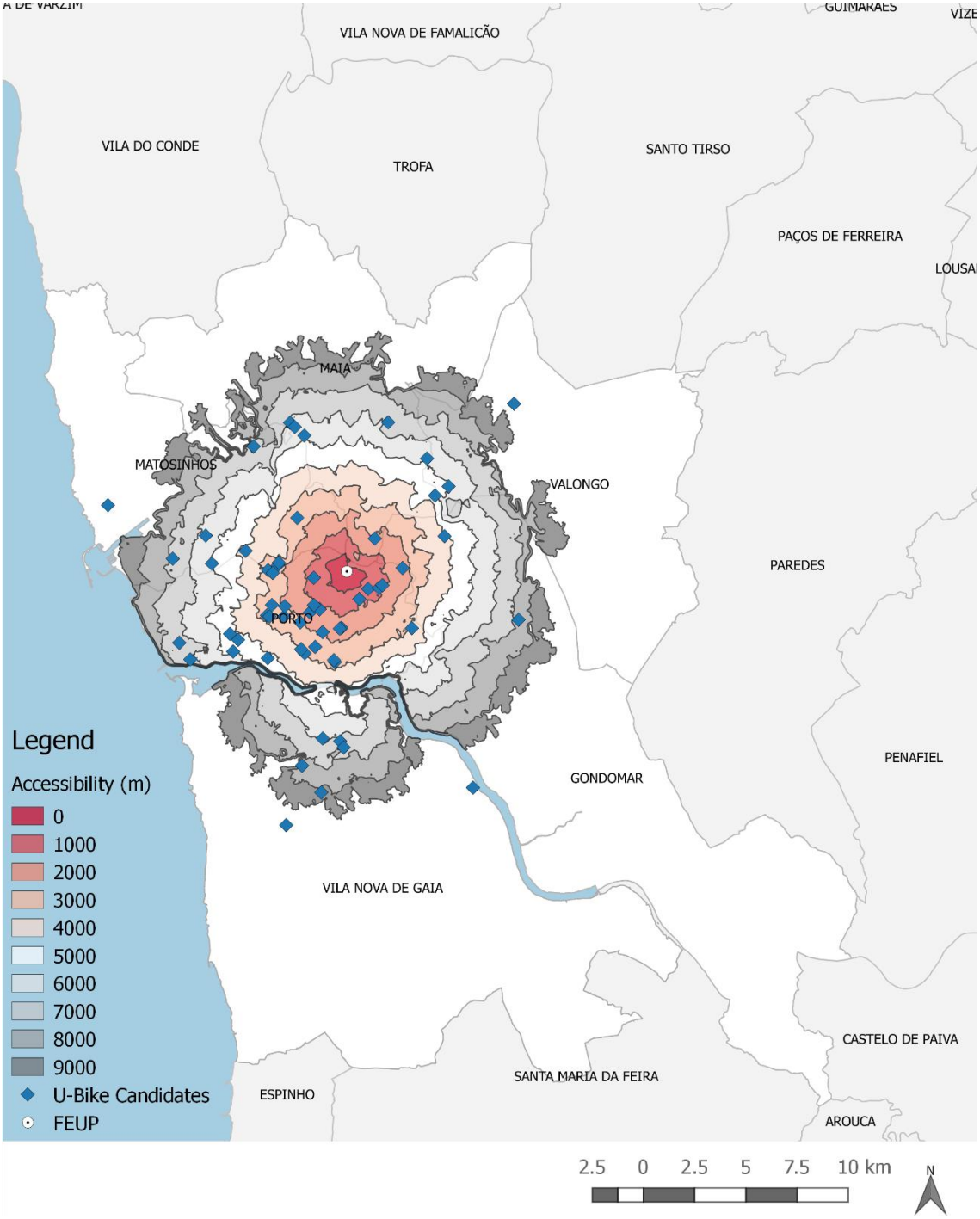


In the second survey, CDUP received 210 applications from all UP community, with 181 people requesting electric bikes and 29 to the conventional ones. Among all the candidates, 62 selected people are from FEUP community. It is important to stress that such number represents a project adherence around *79%* taking into consideration the number of bicycles available. However, if we consider the whole UP community[16], which counts with approximately 31820 students, 2365 teachers and researchers and 1577 non-teaching staff - 35762 people in total - the embracing project and interest rate is around *0,58%.* Such extremely low number might be a consequence of lack of initiatives and incentives intended to increase awareness around sustainable modes of transportation, as well as a lack of promotion measures.

[16] Based on the Report *Uporto em números* 2016-2017

The Map 4 below illustrates FEUP applicant's location, and FEUP as the focal point – destination location - surrounded by accessibility buffers, which were set from 1000 to 1000 meters until reach 10km distance from the focal point.

Map 4 - U-Bike applicants and the accessibility conditions



4
FINDINGS

4.1. ATTITUDES AND PERCEPTIONS TOWARDS CYCLING

Regarding the current mobility patterns and travel behaviour, this dissertation found a high level of motorisation in the university community, with a great share of people who use automobile even within reasonable cycling and walking distances, as other studies have already found (Kaplan, 2015). Furthermore, those who travel bigger distances preferred individual transportation modes than public and alternatives ones. Such phenomenon can be linked with a lack of municipality and university's planning policies to constrain car usage, which makes such mode of transportation more convenient and accessible, affecting the transport network system directly. In fact, this research found the university's modal split matches with the current modal split found in the Greater Oporto, which is car-orientated. As a result, the city has been experiencing an increase of pollution level and traffic, not only in the campus environment but also from the downtown throughout inner areas, as found in the literature reviewed (Silva, 2014).

Furthermore, socio-economic characteristics such as age, gender, and position in the university community played some expected roles in the transportation mode choice. As assessed in other researches, in this sample the bicycle usage was higher amongst men than women (North, 2012; Molina-García *et al*, 2015; Gatersleben and Appleton, 2007), youngers (Shafizadeh, 1997), and those who lives in a reasonable cycling commuting distance, within 30 minutes or 5 km (Molina-García *et al*., 2013). However, while some studies have shown that active commuting remains low for students (Kaplan, 2015), this dissertation found that walking to the university is the third preferred mode of transportation, while bicycle remained in a low rate.

Surprisingly, teaching and non-teaching staff and PhD students have the highest percentage of bicycle usage in this sample. In the same time, these groups have the highest automobile usage rate and ownership in the sample – Chart 2.

Regarding the role of gender in the modal split, the share of men who use private automobile is just slightly higher than the women usage. Meanwhile, women use more public transport *41%* than men *29%*. Regarding active modes of transportation, men cycle and walk to the university more often than women

By analysing the respondents' age and the transport mode choice[17], the age gap of 21-25 years old have the highest number of representatives who cycle or walk to the university, while the highest usage of private modes of transportation was found within older people, those above 36 years old. In general, those between 18 and 35 years old use more public transport – Chart 3.

Chart 2 – Sample characterisation by university position and transport mode (%)

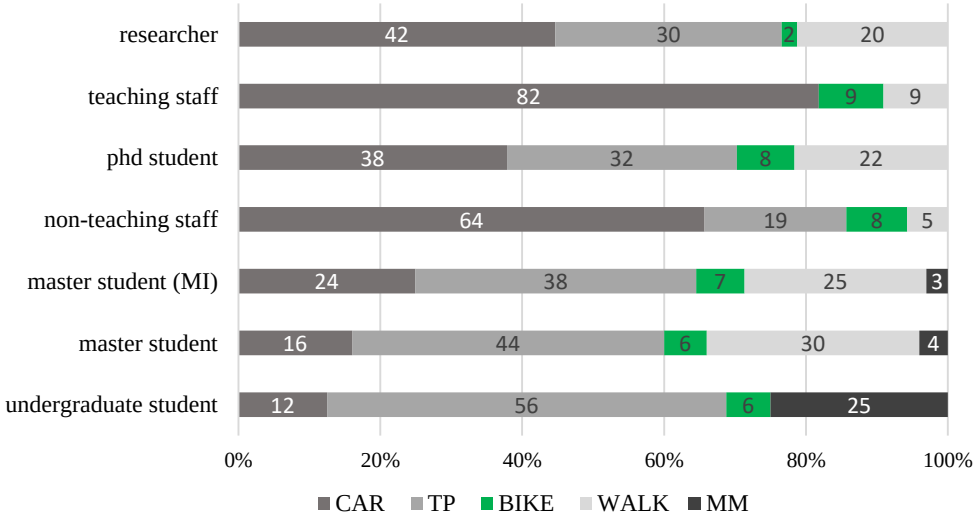
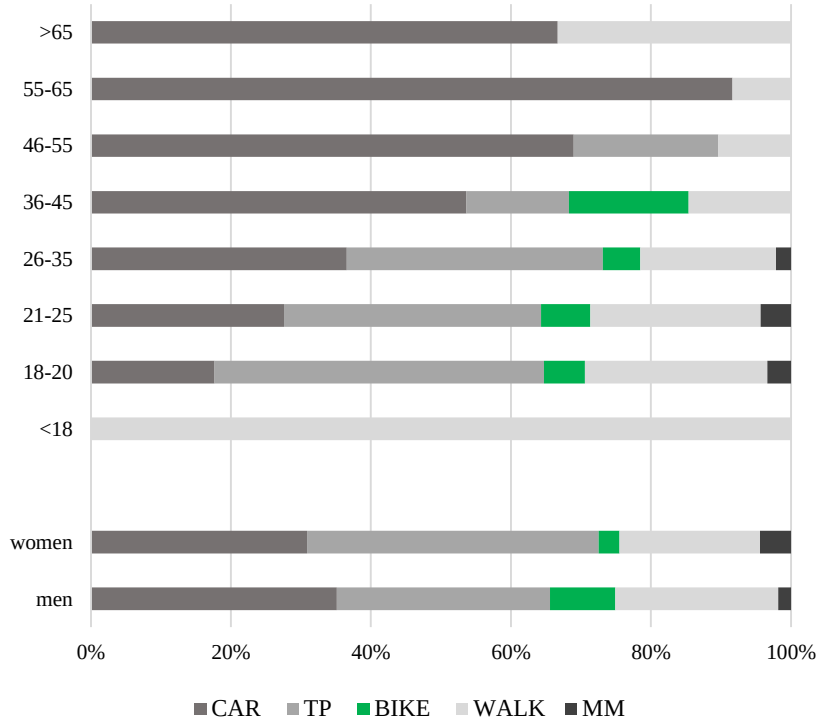


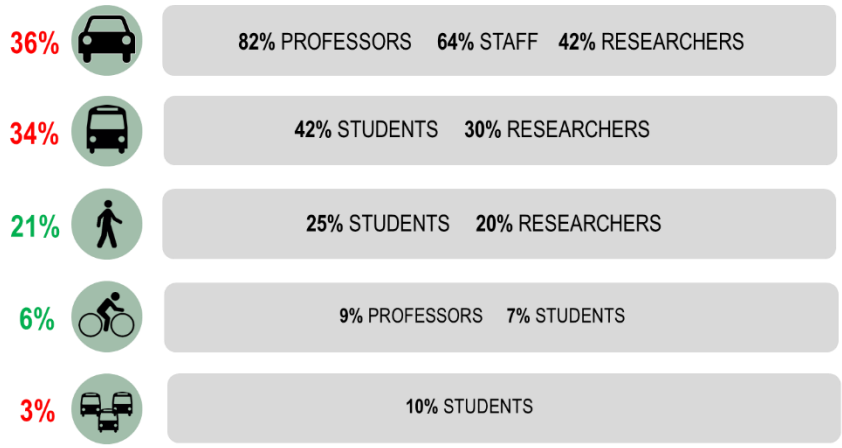
Chart 3 – Sample characterisation by age, gender and transport mode (%)



[17] TP Public Transportation (bus, train, metro, tram) ; MM -combination of more than 2 transport modes.

The first survey section gathered information regarding various aspects of respondent's daily commute, such as transport mode chosen, journey duration, address, arrival and departure time. From data collection, automobiles were the most used mode of transportation *36%*, followed by public transport *34%*, walking *21%*, cycling *6%* and *3%* of the respondents use more than two different transportation modes in their daily travels, as illustrated in Figure 10 bellow:

Fig. 10 - Sample Modal Share



This research assessed the respondent's psychological perceptions and intentions associated with the journey and the current transport mode chosen. The Chart 4, gathered the perceptions into two different ways. The first one explored six states of mind associated with the journey travelled, half are positive views and the others, negative views: fun, relaxing and interesting — stressful, boring and depressive. The second section assessed the travel distance perceived. Such analyses excluded motorcycle users since the number was not representative, and all public transportation users – metro, bus, and train – were grouped into a single profile TP.

The negatives perceptions were predominant higher for those who use motorised modes of transport to go to the university – Car, TP, MM - than for those who use active modes – Bike and Walk. Among all groups, MM counts with the highest negative perception of the journey, highlighting all three negatives perceptions. Car and TP users highlight two negative states. Approximately *71%* of MM users consider their journey stressful. This number is slightly high for drivers with *44%* and TP users *37%*. A great share of TP users *82%* consider their journey boring, and MM agreed *79%* in such perception. This perception is above the average for drivers *39%*. Just MM users highlight the perception – depressive - in this sample, counting *43%* of the respondents, all the other groups have such perception below the average rate.

The respondents, who use active modes of transportation, perceived the journey more positively, as illustrated in the Figure 11. Above all, cyclists have the highest positive view, highlighting all three positive states: *81%* considered the journey relaxing and *72%* considered it fun and interesting. For walkers, it was highlighted the relaxing sensation at *64%*, while the other two positive perceptions are slightly above the average, fun with *35%* and interesting *33%*.

Chart 4 – Perceptions of the journey in different transport modes (%)

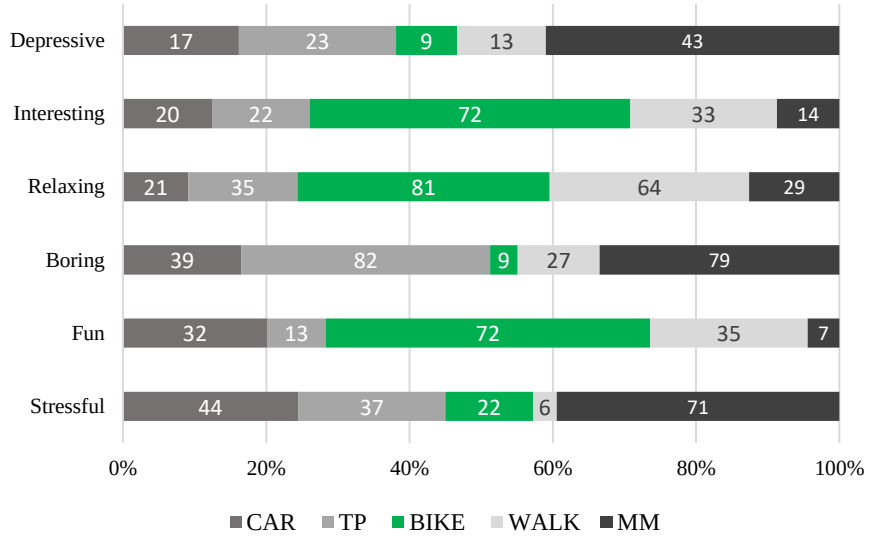
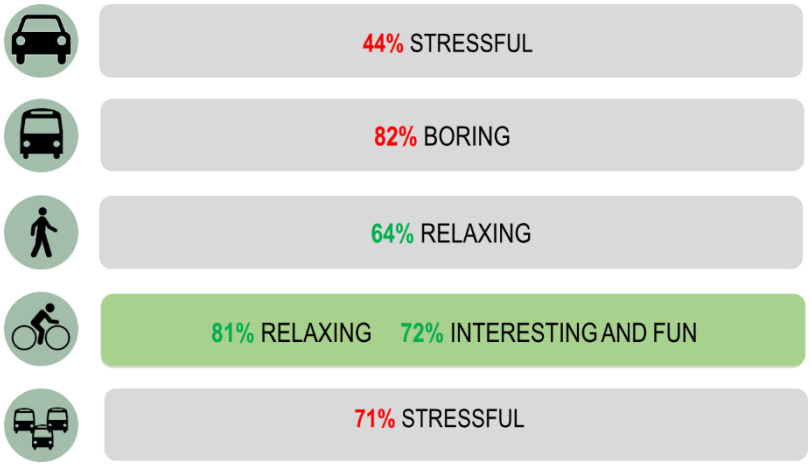
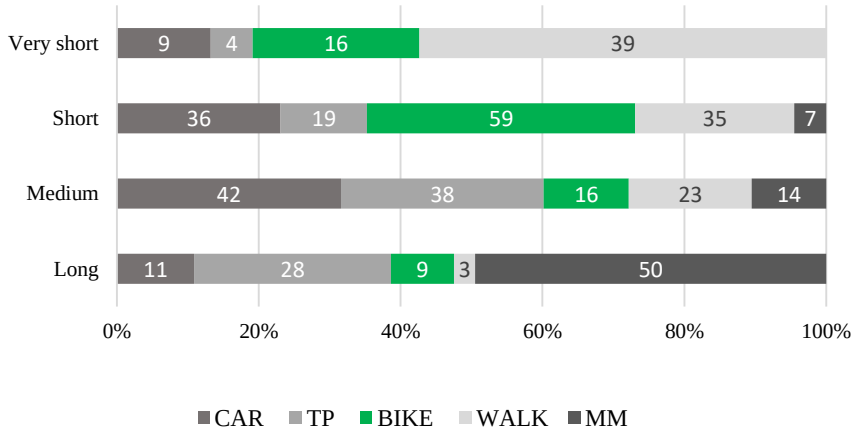


Fig. 11 - Representative perceptions in different transport modes



By analysing the travel time perceived, a share of *79%* of MM users perceive their distance travelled long, while the active ones perceived their journey distance short: *75%* of cyclists and *74%* of walkers. Car and TP users travel medium distances, both with a share of *42%* and *38%*. However, a great share of car users *45%* perceived their commuting travel short, as well.

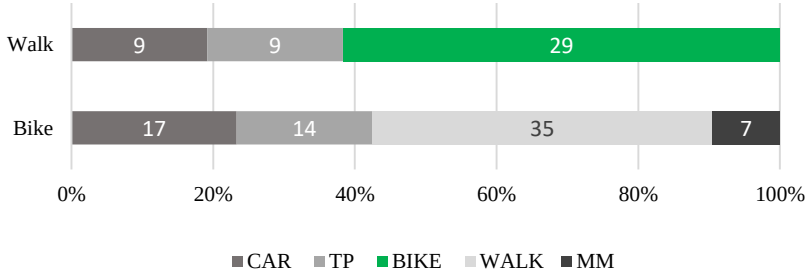
Chart 5 Perception of the journey – Travel Time (%)



Within such analysis, it is possible to associate the commuting time spent with the prevalence of positive or negative personal perceptions. Those who spent more time commuting have highlighted more negatives views of the journey than the positive ones. When people spend less time commuting, as cyclists and walkers, the journey is perceived more positively.

The respondent's probability to use different transportation modes to commute to the university was assessed, precisely towards sustainable modes - bicycle and walking. The declared intention of a sustainable modal switch towards bicycle was quite low in this sample. Just *17%* of car users, *14%* of TP and *7%* of MM users may consider use bicycle for commuting purposes, even though both groups have a high rate of representatives who own a bicycle for daily use – *69%* of drivers, *57%* of MM, and *43%* of TP users. Such expected transportation switching has better results within the current active modes users: *35%* of walkers could ride a bicycle to the university, while *29%* of cyclists could walk.

Chart 6- Intentions towards a sustainable modal switching (%)



Regarding cycling frequency within different trip's purposes, more than half of respondents never use the bicycle for shopping duties - diverse *62%* and grocery *58%*. In fact, within this sample, people who always go shopping by bicycle is below *2%*. Such phenomenon can be linked with the inconvenience of carrying big volumes while cycling, as well as, the lack of parking spots in the majority of commercial places.

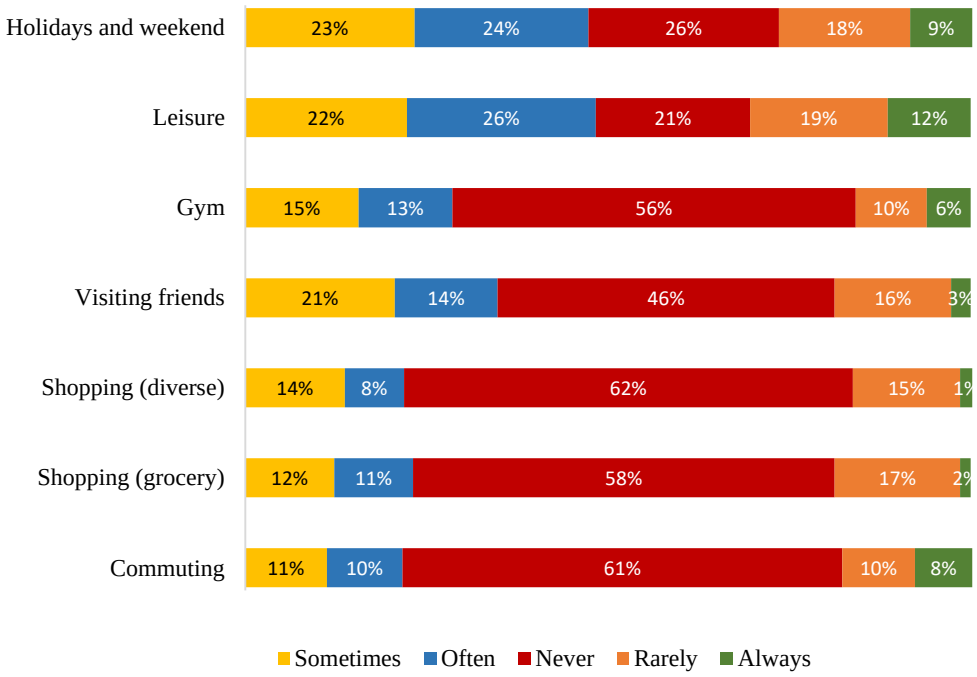
Furthermore, more than half of respondents never use the bicycle for commuting purposes at *61%*, while a low share of respondents *8%* always do. In fact, as previously explored at the beginning of this chapter,

the highest chosen mode of transportation to go to the university was the automobile *36%*, followed by public transport *34%.*

Although a great share of respondents agreed that cycling is a healthy mode of transportation and good for the environment, more than half of the respondents do not cycle for any purpose and do not use it as a way to practice physical exercises. In this case, have conscious of the positive aspects of the bicycle does not mean better attitudes towards cycling.

In this research sample, the bicycle frequency was higher within leisure activities, as well as on holidays and weekends. However, the bicycle frequency remains quite below the average for other activities such as shopping, commuting and to visiting friends. The Chart 7 below illustrates the bicycle frequency split in the main travel motives found in this sample:

Chart 7 - Bicycle frequency split in the main travel motives



Regarding the social circle influence on the mobility choice and behaviour, *55%* of respondents agree that friends and family would support them in case of undertaking cycling to the university. However, almost half of the respondents do not know any person who commutes to FEUP by bicycle, with a share of *48%.* Meanwhile, *47%* of respondents know at least one to three people who cycle to the university and, *5%*, more than four people. Such low rate of visible cyclists in the university environment may constrain the uptake of cycling in a daily schedule.

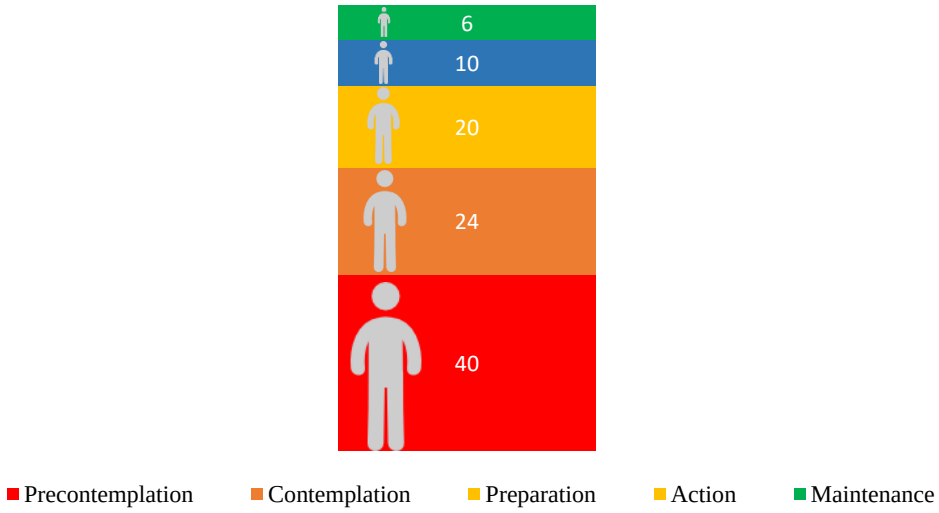
4.2. EVALUATION OF THE PROJECT'S POTENTIAL

To examine the bicycle provision potential to induce a take up and maintenance of cycling, the respondents were categorised according to their current behavior and intentions towards cycling usage, throughout the application of the Transactional Model of Behavior Change (Gatersleben and Appleton, 2007; Prochaska, 1994).

According to the answers collected[18], the last BCS group concentrates an expressive number of respondents. Indeed, *40%* of the sample is in the *Precontemplation* stage (PC), in other words, representing those who do not cycle to commute to the university and do not want to do so in the future. The second highest population is in the *Contemplation* stage (C), with a share of *24%* in this sample. Such group does not use the bicycle for commuting purposes, but there is a slight possibility to do so in the future. The third group of people, which is constituted by *20%* of the sample, are in the *Preparation* stage (P), representing those who rarely or sometimes used a bicycle to travel to the university and have considered using one in the future. The fourth group – *Action* stage (A) - representing a share of *10%*, are those who often travel to the university by bicycle. The last group – *Maintenance* stage (M) *6%* - represents those who travel by bicycle to the university every day.

The perceived travel time spent was higher within PC respondents if compared with the other BCS groups. Those who travel to university by bicycle daily, averagely spend 16 minutes in the journey, while those in the last stage spend 34 minutes on average, using motorised forms of transport. The Chart 8 below illustrates the number of representatives in each BCS group, found in this research.

Chart 8 - BCS representatives (%)

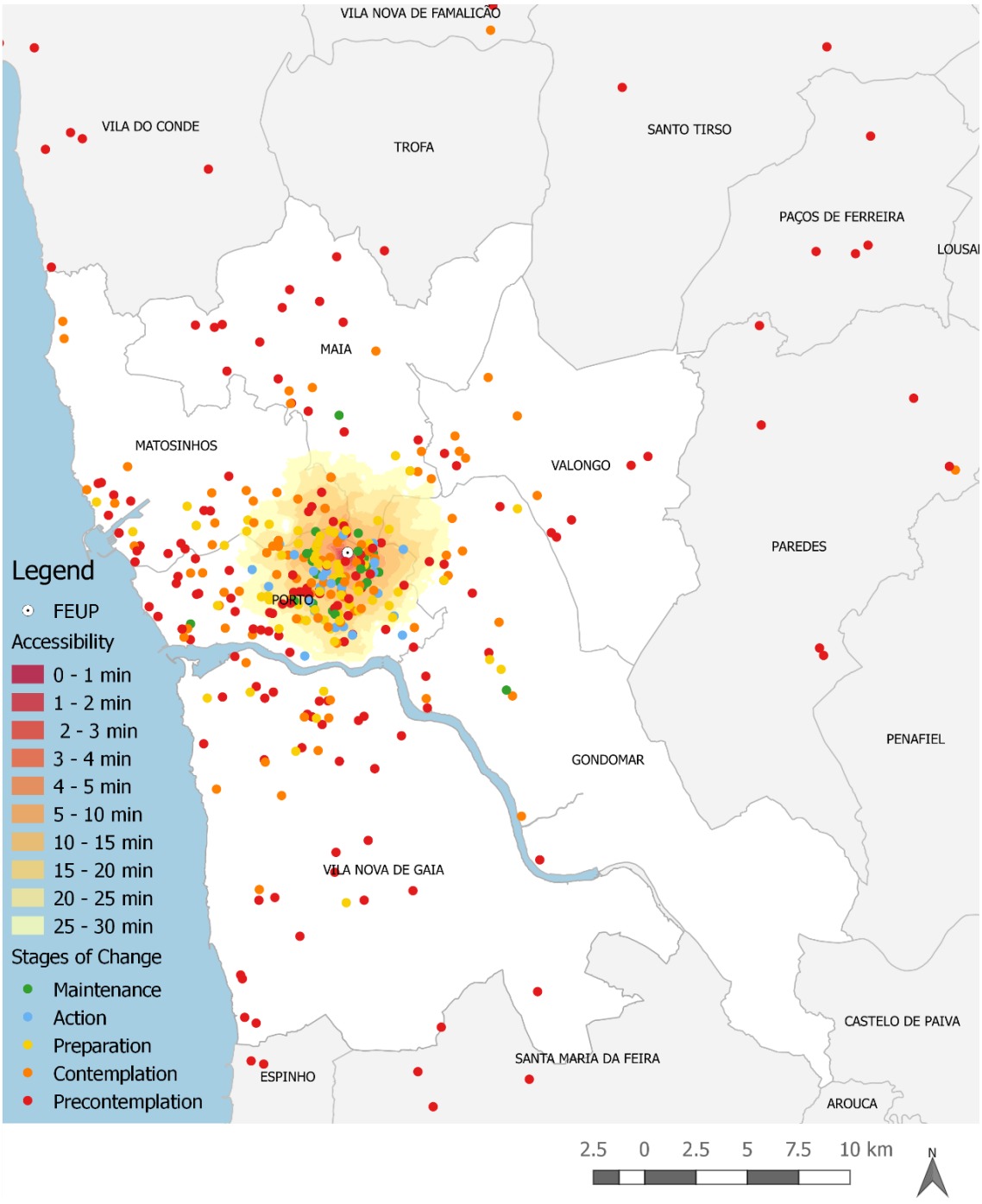


Throughout the spatial analysis[19] – see Map 5 – it is visible that with the increase of the distance to be travelled, there are more representatives of the last BCS group spread in the urban fabric. While, inside the BAZ, and closer to the faculty, there are more representatives already in action and maintenance. The easiness and flexibility of access the faculty by bicycle in such zones explain such phenomenon.

[18] Survey variables: (1) how often they used a bicycle to travel to the university and (2) based on the respondent's intention to use a bicycle for commuting purposes in the future

[19] Spatial maps stratified by each BCS group attached in the appendix.

Map 5 - BGS profiles location



The more restrictive group – *Precontemplation* – has the highest number of representatives in this sample, which have their origin/home not only in the downtown but also in the inner areas of Great Oporto. Such group usually travel longer distances than the others BCS groups. However, a representative share of this group *21%* live inside the BAZ but do not consider use bicycle for commuting purposes.

The second group – *Contemplation* – also has a considerable share of representatives located in the inner parts of the city, but not in the same extension as the first one. In this case, the number of people located

inside BAZ is expressive, with a share of *45%*. Such group has never used a bicycle to travel to the university but consider slightly the possibility to do so in the future.

From such location analysis, the third stage – *Preparation* – is the group, between those who do not cycle for commuting purposes, with the highest number of representatives living inside the BAZ, with a share of *67%*.

Amongst those who cycle to the university often or daily, the action group has *70%* of representatives living inside the BAZs, while the maintenance group has *90%* of representatives living inside the BAZs.

This research found the highest car ownership level among the more restrictive group towards cycling, in fact, *54%* of PC respondents own a car, while such level is low for those already in action *12%*. This frame is slightly different when analysing bicycle possession. All BCS groups have a great share of respondents who own a bicycle, which does not mean that the bicycle usage for commuting reason is high.

The last BCS groups – *Precontemplation and Contemplation* – have a great share of representatives who never ride a bicycle, both *49%*, and *36%*, for any purpose. Furthermore, such groups have demonstrated a slight bicycle frequency, since *22%* and *23%* ride a bicycle just once per month. The most promising bicycle frequency usage, between those who do not use the bicycle for commuting purpose, was found in the *Preparation* stage group. They usually make one trip *30%*, or 2 to 3 trips per week 30%, which is representative, however, such trips are not for commuting purpose. Not surprisingly, the highest cycling frequency was found between the *Action* and *Maintenance* groups, counting 4 to 7 trips per week.

Regarding gender and cycling usage, a great share of women is in the two earliest BCS – *Precontemplation* 52% and *Contemplation 40%.* Just *2%* of the women use the bicycle for daily commuting in this sample. Such profile needs special attention and encouragements to embrace such mode of transportation in a daily schedule.

Chart 9 – Cycling Frequency (% by each BCS group)

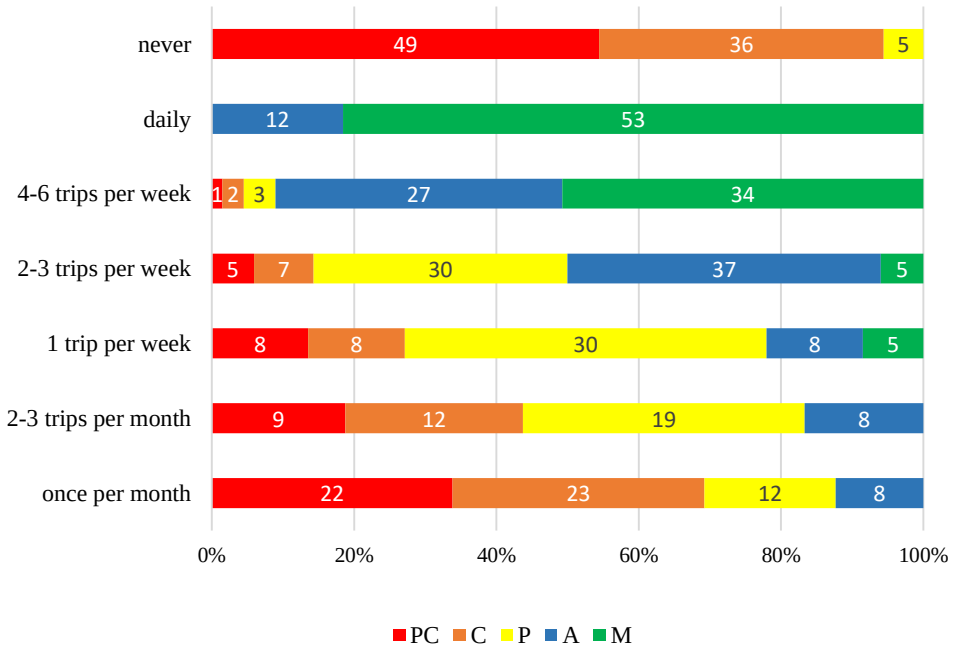
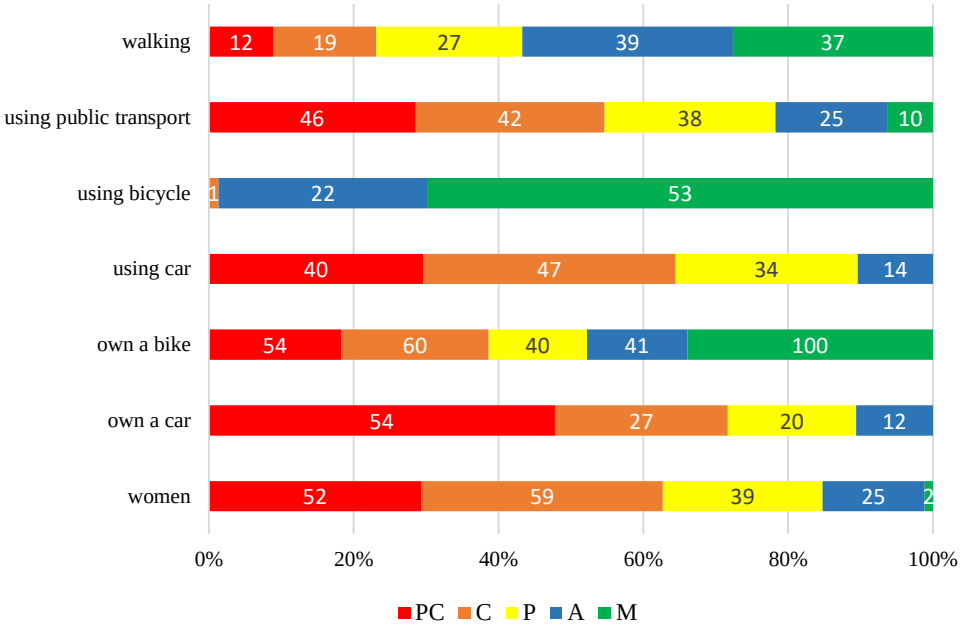


Chart 10 – Background variables (% by each BCS group)



As a way to understand what motivates these different groups towards cycling, this research explored attitudes, personal and structural barriers perceived in different stages of change. Above all, great share respondents from all BCS groups agree that riding a bicycle is an enjoyable activity, with an average rate of agreement of *88%*. Just the PC group has demonstrated an agreement rate below this average.

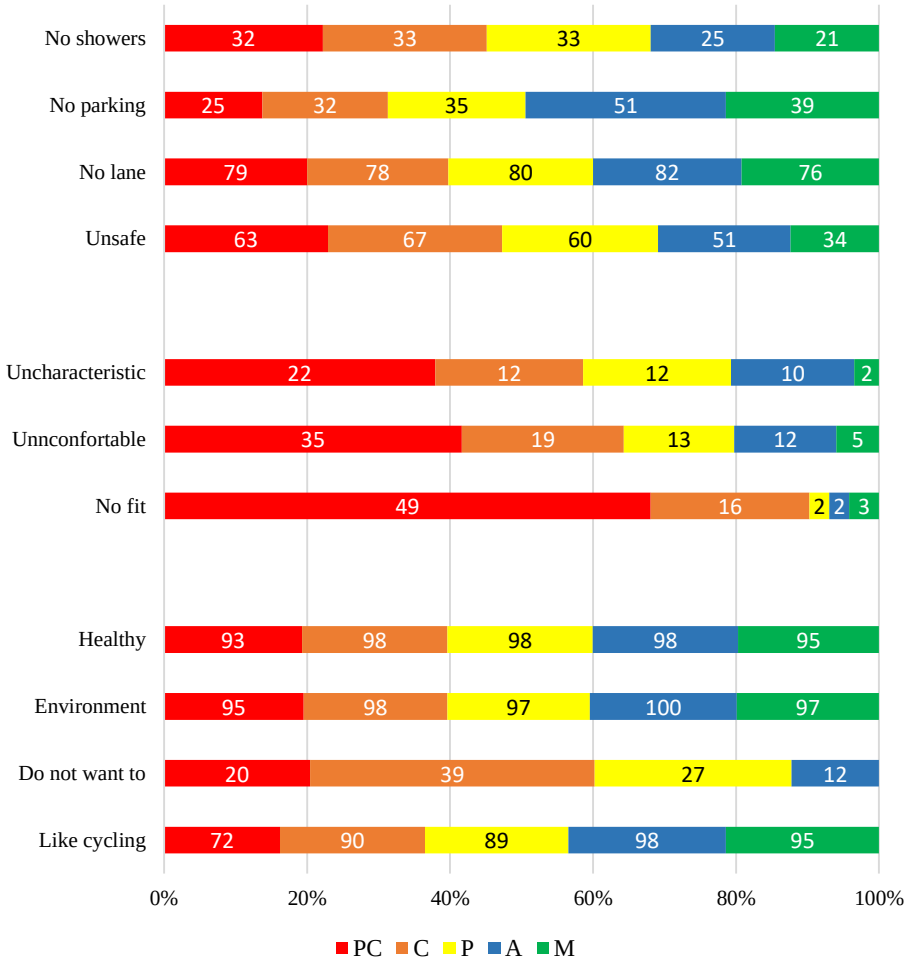
Even though all groups agree that the bicycle usage is environmentally friendly and healthy, with a great rate of agreement, both *97%* and *96%* in average, many people from the first three BCS groups – *precontemplation 20%*, *contemplation 39%* and *preparation 27%* – do not use the bicycle simply because they do not want to.

Between all the stages, those who had never contemplated cycling perceive more personal barriers than the others BCS. Almost half of the PC respondents, *49%*, consider themselves without a good physical condition to ride a bicycle to the university. While this rate dropped to *16%* in the next stage – *Contemplation* – and to *2%* in the *Preparation* stage. Furthermore, *35%* of PC respondents would be uncomfortable and *22%* uncharacteristic in a bicycle. In other words, they do not feel or imagine themselves physically and socially comfortable in this mode of transportation. By analysing throughout the BCS groups, it is noticeable that the personal barriers decrease when we move to the next stage, close to the action.

Concerning structural barriers perceived, the current transport and urban network, as well as the university bicycle facilities play an important role in the likelihood of cycling. Between all stages, instead of the maintenance stage, more than *50%* of respondents perceived the built environment unsafe for cyclists. This perception is higher for those who are contemplating using the bicycle to go the university with an agreement rate of *67%*. Not surprising, all groups agree, that there are no physical conditions and cycle paths available, in their route home-FEUP, the highest agreement in this matter is among those who are prepared to start cycling *80%*. Such negative view of the built environment can be associated with their hesitation to uptake such mode of transportation for commuting purposes.

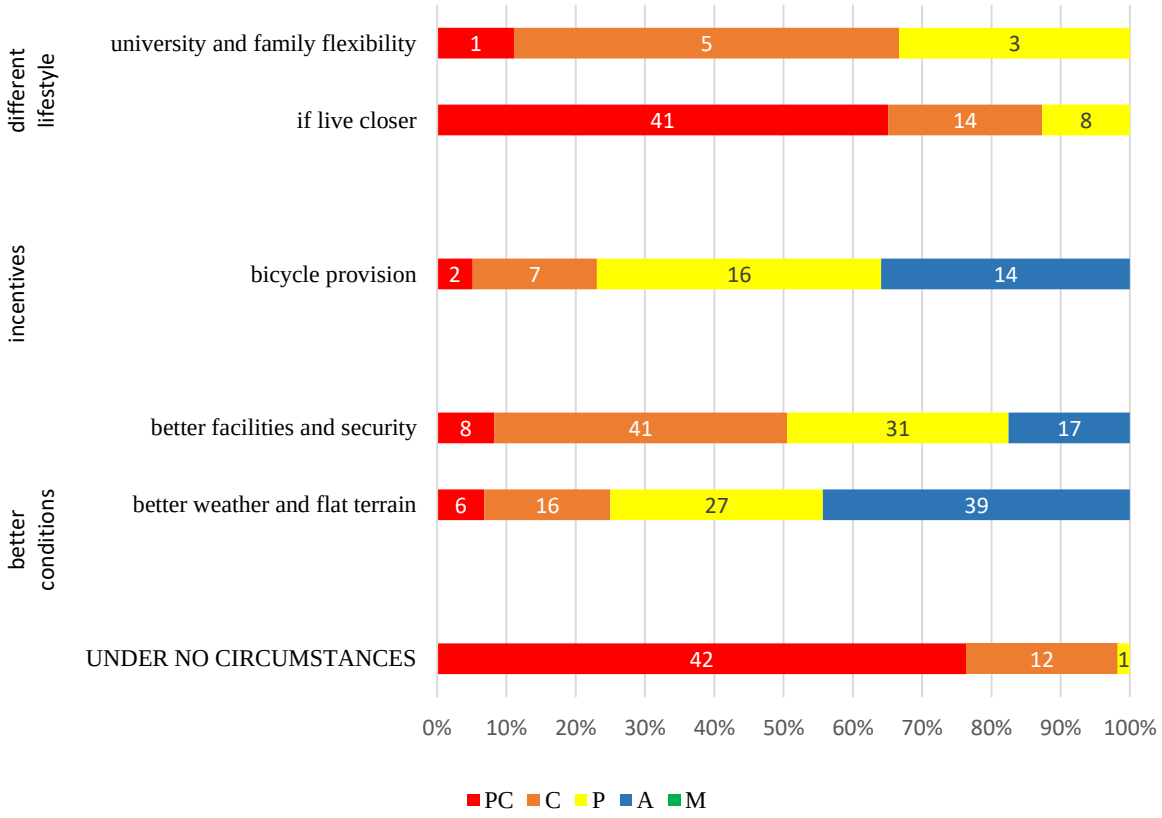
According to Chart 11, A great share of respondents does not have an opinion regarding the university facilities - parking and showers. Such phenomenon can be linked with the lack of communication and promotion measures. Those who use bicycle often and daily - *Action* and *Maintenance* stages – have stressed that the university does not offer suitable, sufficient and secure parking spots in the campus setting, both *51%*, and *39%*.

Chart 11 – Attitudes towards cycling (% by each BCS group)



This research assessed under what circumstances the university constituents would be willing to cycle to the university more often. Based on the variety of aspects within each BCS group, the responses were recorded into three categories of analysis: (1) Different lifestyle; (2) Incentives; (3) Better conditions and (4) Under no circumstances – see Chart 12 below:

Chart 12 – Respondents mentioning circumstances under which they would be willing to cycle to the university more often (% by each BCS group)



The respondents who had never contemplated cycling to the university claimed they are not willing to cycle to the university under any circumstances, with a share of *42%.* The other share asserted that they would cycle to the university if they live closer. Such group is the most difficult one to change their mobility behavior.

For contemplative respondents, *41%* have claimed that they would cycle more often if the city and the university environment provide better facilities and security Respondents who were prepared to start cycling also agree with such statement in *31%.*

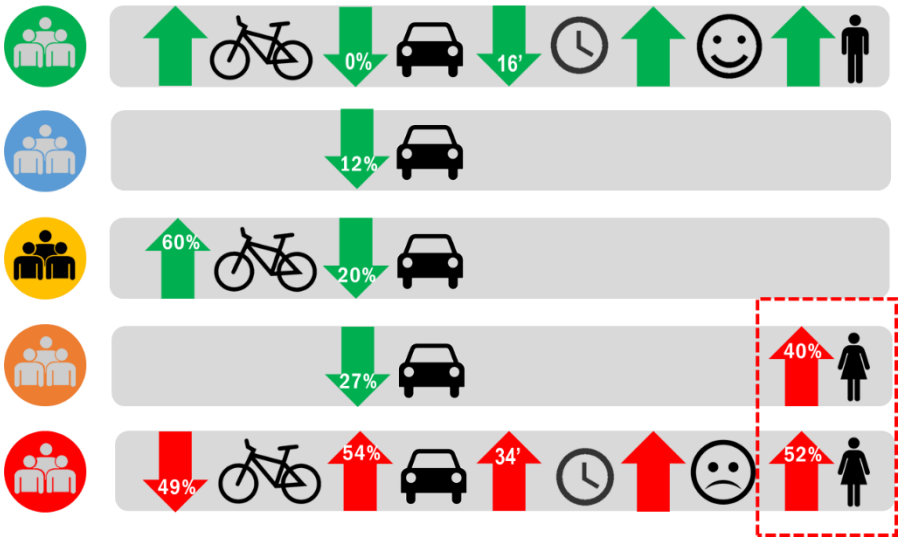
For people in action, better weather and flat terrain are determinants for their bicycle usage level, with an agreement rate of *39%.* Such group does not use bicycle often during the winter season. Also, they choose another transport mode to go to the university on rainy days.

Concerning U-Bike project investigation, fewer respondents have claimed that they would cycle to the university under bicycle provision. Between all groups, the preparation stage *16%* and action stage *14%* have a quite low agreement in such mater but is still above the average *7.8%.* In fact, as explored above, more than half of the respondents already own a bicycle for daily usage. Thus, just providing a bicycle is not enough to change and sustain such mobility behavior.

Throughout analyzing the extreme stages, it was noticed that those who use the bicycle daily have the lowest car ownership level in the sample, whereas those who never cycle for commuting purposes have greater possession. This research also revealed that the *preparation* stage concentrates those who are ready to use the bicycle for commuting trips, since there is a current good frequency of bicycle usage

and low rate of automobile ownership. Regarding gender, the *maintenance* stage is constituted mainly by male population, while the groups more restrictive to the use of the bicycle – *precontemplation* and *contemplation* – concentrates almost the totality female audience of the sample, as illustrated in the Figure 12.

Fig. 12 Main findings regarding cycling usage potential (% by each BCS group)



Color scale: green - maintenance stage; blue – action stage; yellow – preparation stage; orange – contemplation stage; red – Precontemplation stage

4.3. EVALUATION OF THE UNIVERSITY COMMUNITY'S POTENTIAL

To explore the university community's potential in changing behavior towards cycling, the needs, barriers and potentialities were explored during the one-week cycling experience, with the aim of understanding in more detail how more people could be persuaded to cycle to the university, as well as asses the favorable target population for such bicycle rental scheme.

Table 5 categorises the volunteers according to their stage of change, gender, current transport mode, nationality, travel time and distance to commute to the university by bicycle:

Table 5 – Volunteers characterisation

	GD.	T.M	NATIONALITY	TIME. (MIN)	DIST. (KM)	THE REASONS BEHIND ACTION STUDY PARTICIPATION
MAINTENANCE						
M1	M	Bike	BR	14	~3	Increase public and planners awareness
M2	M	Bike	BR	5	~1	Contribute to the research
M3	F	Bike	BR	12	~3	Contribute to the research

ACTION						
A1	F	Bike/ Car	ES	10	~2.5	Increase public and planners awareness
A2	F	Bike / TP	BR	10	~2.5	Increase public and planners awareness
PREPARATION						
P1	M	TP	PT	25	~5	Want to start cycling to the university
P2	M	TP	BR	18	~4	Want to start cycling to the university
CONTEMPLATION						
C1	M	TP	PT	25	~7	Physical activity / Enjoy the good weather
C2	M	Car	PT	30	~10	Want to start cycling to the university
C3	M	TP	PT	25	~6	Want to start cycling to the university

M1 – volunteer 1, from maintenance stage; M2 – volunteer 2, from maintenance stage; M3 – volunteer 3, from maintenance stage; A1 – volunteer 1, from action stage; A2 – volunteer 2, from action stage; P1 – volunteer 1, from preparation stage; P2 – volunteer 2, from preparation stage; C1 – volunteer 1, from contemplation stage; C2 – volunteer 2, from contemplation stage; C3 – volunteer 3, from contemplation stage; M – male; F – female; BR – Brazilian; ES – Spanish; PT – Portuguese; ~ Approximately; B.A – Bike activist; Gend. – Gender; T.M – current transport mode; TP – Public transport.

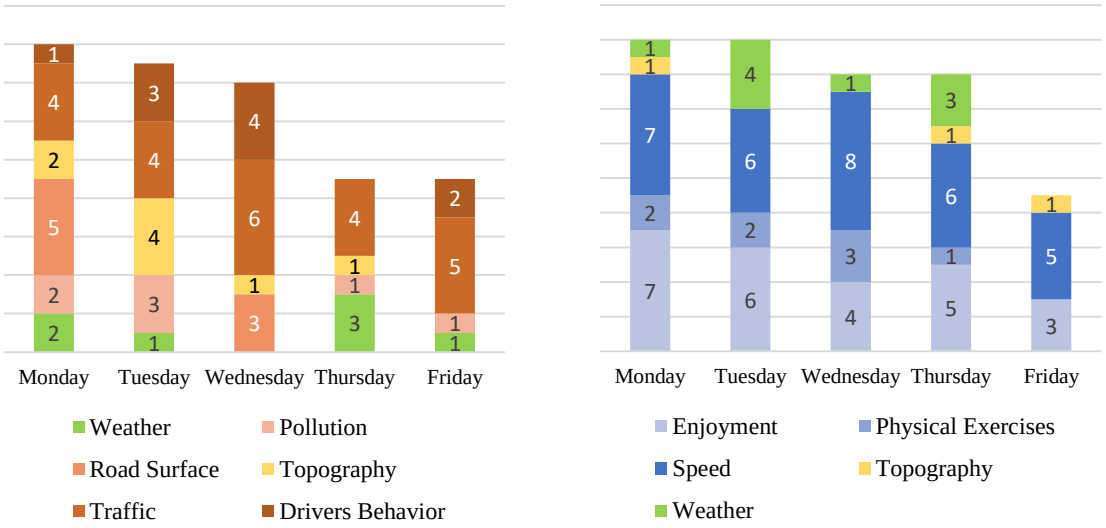
4.3.1 Travel Diaries' Results

The motivations behind the participation in such trial varied along the sample. Mainly, the volunteers in *maintenance* decided contributing to the research in a way to support the increase of the public and planner's awareness regarding bicycle use. Likewise, the active participants highlighted such reasons as the motivator. Furthermore, there were two participants – **M3** and **A2 -** who consider themselves bicycle activists. The last two groups of the sample – *Preparation and Contemplation* – have claimed that such trial could be a good opportunity for them to test the possibility to start cycling to the university, as well as to check the possible barriers and potentialities before establishing such new mode of transport choice. Just one volunteer **C1** has seen this trial as an opportunity to do exercises and enjoy the good weather.

During the experiment, the first groups – *Maintenance and Action* – have not changed their current route to go to the university. In fact, just **M1** changed his route slightly, due to another activity scheduled within the journey. This frame is quite different within the last groups – *Preparation and Contemplation* – with a great share of representatives *80%* changing their commuting route during the week. The main reasons for such behavior were linked to the process of discovering the best path. In fact, those participants have studied the urban network in a way to find quicker and directness routes, with better accessibility conditions to reach the Asprela campus. Furthermore, volunteer **C3** also took into consideration the quality of pavement surface to choose the best route. After this stage, all participants have kept the new route, during the remaining trial days. Just one participant – **C2 -** has not changed his route during the week. In fact, in the past, he had already tested the possible routes to go to the university in a way to avoid traffic and pollution, by choosing a green path.

Likewise, the travel diary's analysis gathered the most pleasant and unpleasant factors related to the journey in a daily schedule. The Chart 13 illustrates the number of times each factor was rated as unpleasant or unpleasant by the participants. The most unpleasant situations reported were the high level of traffic in the roads, followed by driver's behaviour and the most pleasant were the speed and flexibility offered by such mode of transport, as well as the enjoyment. It is also visible that weather and topography play a dual role in journey perceptions, both positive and negative.

Chart 13 - Unpleasant (left) and pleasant (right) experiences during the action study week-trial (n)



Furthermore, Table 6 below presents the participants' perceptions of the journey, categorised in a colour scheme, through 4 groups of factors. The colour green highlights the positive perceptions and red the negative ones.

Table 6 – Understanding cyclists perceptions of the journey

	FACTORS	M1	M2	M3	A1	A2	P1	P2	C1	C2	C3
TRIP	Journey Duration										
	Speed										
	Flexibility										
ENV.	Topography										
	Weather										
	Pollution										
	Traffic										
STR.	Ground Pavement										
	Urban form										

M1 – volunteer 1, from maintenance stage; M2 – volunteer 2, from maintenance stage; M3 – volunteer 3, from maintenance stage; A1 – volunteer 1, from action stage; A2 – volunteer 2, from action stage; P1 – volunteer 1, from preparation stage; P2 – volunteer 2, from preparation stage; C1 – volunteer 1, from contemplation stage; C2 – volunteer 2, from contemplation stage; C3 – volunteer 3, from contemplation stage; Env – Environmental; Str – Structural; Subj – Subjective.

Regarding the first factor, all participants had at least one positive view of the trip. In fact, *60%* of the participants considered the journey duration feasible, with some participants – **P1** and **P2** - surprised since their time journey was shorter by bicycle than with their current transport mode. The participants considered the flexibility and speed during cycling as a pleasurable experience, in a share of *50%* both. None participants have claimed negative perceptions in this factor.

The second factor gathered perceptions associated with the environment. The city's topography was evaluated in both positive and negative ways. In fact, some volunteers – **M1**, **P1,** and **C3** - have reported pleasant moments while cycling in down-hill routes and some difficulty to go into up-hill routes. The weather is another environment determinant of cycling frequency in this sample, with a great share of *40%* of participants not cycling during rainy days. In fact, just the *Maintenance* stage had all the representatives cycling, even though the weather conditions were not favorable. The most unpleasant environmental factor was linked to the pollution and traffic, mainly for the last BCS groups – *Preparation and Contemplation* – with a share of *80%* of agreement. Indeed, these participants have travelled more miles than the first groups, in order words they have faced more adversities and contact with motorised transportations modes during their journey.

The third factor, concerning the structural urban form perceptions, counted with a great share of unpleasant views, from all participants: *50%* of the participants have perceived the ground pavement is not favourable for cycling since it had a rough surface which constrains speed development. Furthermore, another half have seen the lack of connectivity in their routes as a difficult barrier to overcome, which constrains the sense of security. A share of *50%* of participants claimed that the current bicycle parking in their neighbourhoods – **P1** and **P2** – and in the university building - **A1**, **C2**, and **C3** – are unsafe. Also, 40% of the respondents have perceived the routes available for cycling too narrow and dangerous, since they felt themselves closer to the motorised forms of transport.

Nonetheless, *30%* have seen the use of the bicycle to go to the university as an opportunity to practice exercises. At the end of the week trial, the last stages – *Preparation and Contemplation* – have perceived themselves fatigued, with an absolute agreement rate. In fact, these groups are not used to cycle to the university, and they have cycled through longer distances.

4.3.2 INTERVIEWS' RESULTS

This reserch conducted interviews with the participants, before and after the experiment, to provide a more in-depth understanding of the behavior and attitudes changing in the sample, providing some indications on the most pleasant and unpleasant situation expected and experimented during the week.

In both before-after scenarios, positive views as the opportunity to do exercises, as well as a to have fun and enjoy the outdoor activity did not change, keeping the same rate of agreement *40%*. The perception that a bicycle is a flexible form of transportation has increased considerably during the cycling trial, from *10%* to *50%.*, while the search for new routes dropped from *30%* to *10%*.

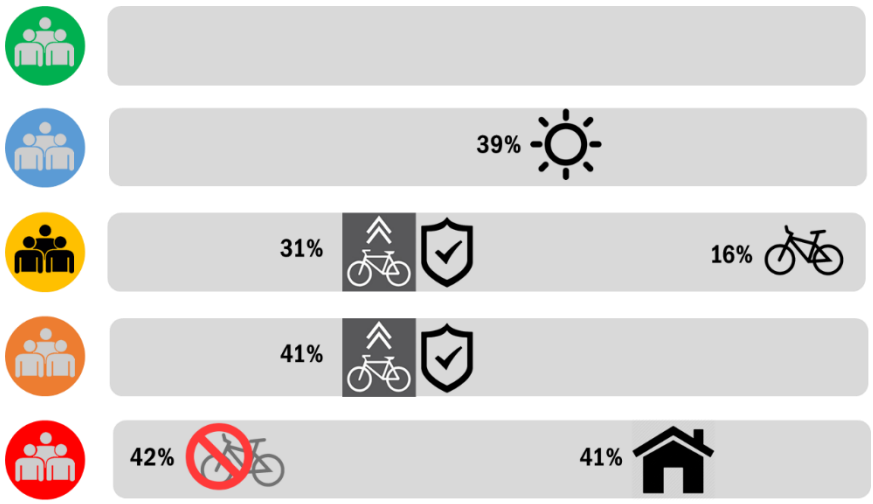
Between the new cyclists, *80%* wanted to keep cycling after the trial. However, just *20%* kept such behavior afterwards, according to the second interview assessment. The reasons behind it varied from the lack of cycling conditions and facilities for *80%* of the participants and the fatigue sensation after the journey for *30%*, in the first week.

During the cycling trial, the negatives perceptions of the route regarding traffic and security safety increased considerably, from *30%* to *60%*. Furthermore, perceptions related to pollution, as well as inconveniences, such as tiredness and sweat, increased from *10%* to *30%*. The negative view of the weather decreased during the trial, from *40%* to *10%*.

All new cyclist claimed that they want to keep traveling by bicycle to FEUP often. The favorable conditions for them keep such behavior are the provision of better bicycle facilities and security *80%*, good weather *10%* and *10%* under bicycle provision. Among the current cyclists, suffer an accident would be the most significant impediment to stop them from cycling to the university. While for the new cyclists, the reasons vary between bad weather *60%*, family or work schedule *20%* and heavy road traffic *20%*.

This research found that bicycle use and maintenance incentives vary across the BCS profiles, as represented in the Figure 13. In the more restrictive group, a larger portion is not willing to use such mode of transportation, while another significant part claims that would cycle to the university if lived closer. The next stages would use the bicycle more often under conditions of better conditions and safety.

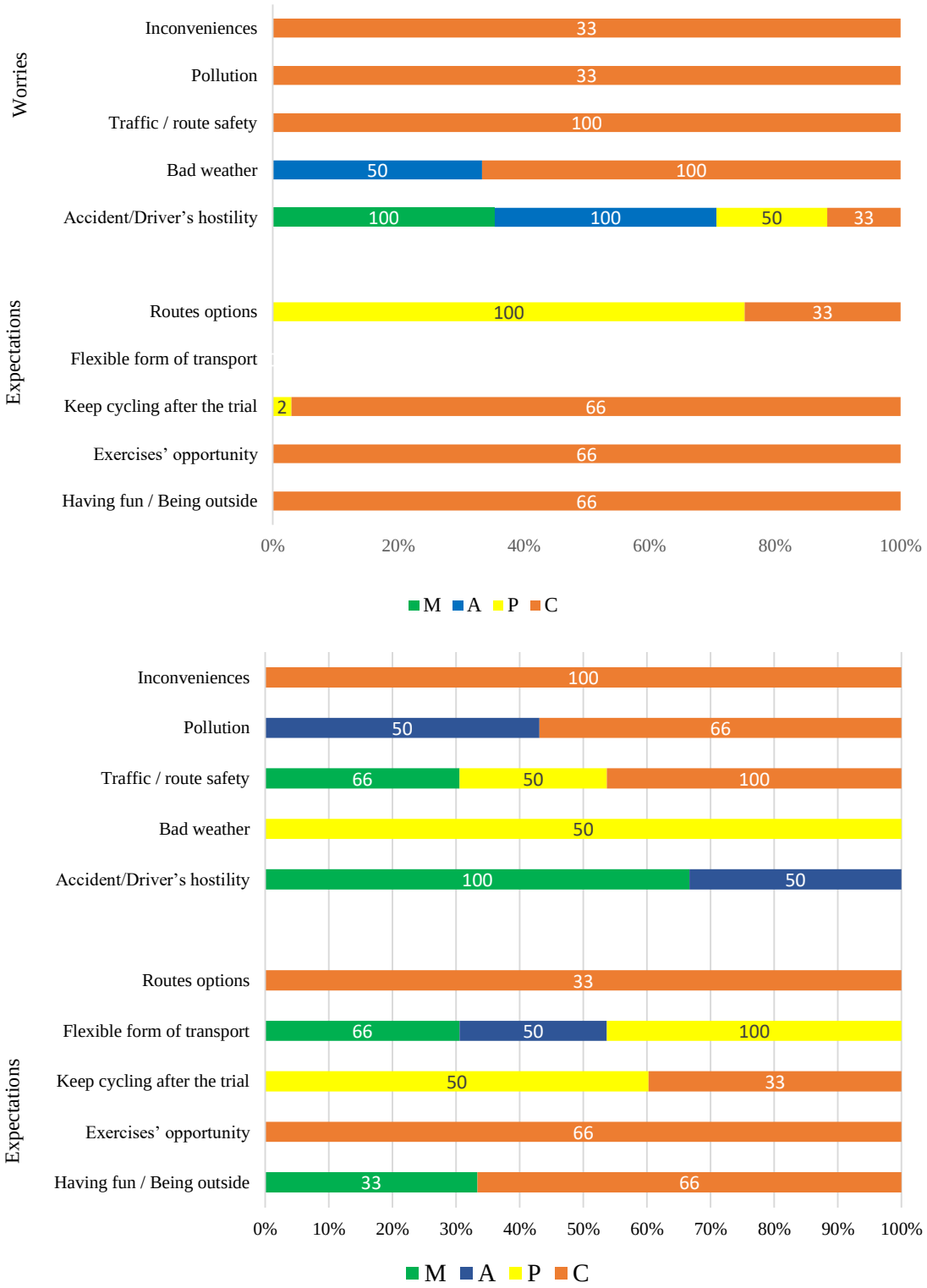
Fig. 13 Main Incentives towards the bicycle usage (by each BCS group)



Color scale: green - maintenance stage; blue – action stage; yellow – preparation stage; orange – contemplation stage; red – Precontemplation stage

Chart 14 bellow indicates the respondent's perceptions changing after experience the one-week cycling trial:

Chart 14 – Expectations and worries **before** and **after** the one-week cycling trial (% by each BCS group)



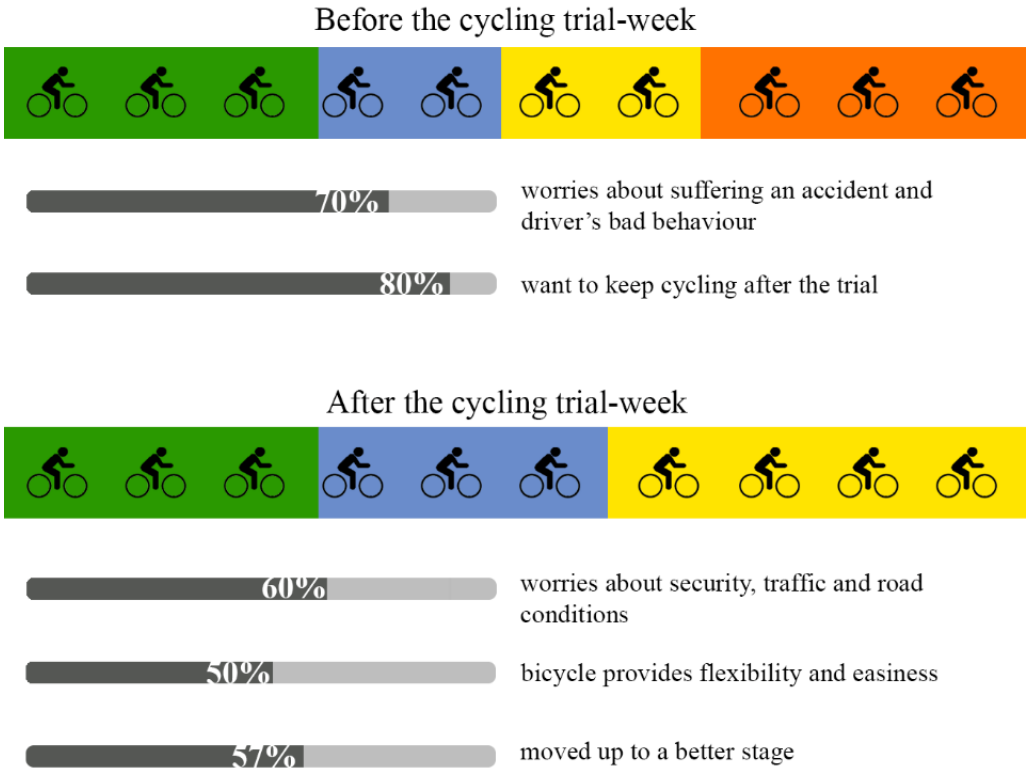
After the cycling experiment assessment, it was observed an increase of self-awareness and better attitudes towards cycling, with a share of *57%* of the participants moving to a better stage in the BCS model.

This research revealed the unattended bicycle access scheme is not determinant to create and maintain such new mobility pattern since barriers as the lack of security, heavy traffic and poor road conditions play an important role on the likelihood of potential new cyclists to keep such modal choice for commuting purposes. The target population should receive support and complementary incentives to keep such behavior and move to the ideal stage, and travel by bicycle in a daily schedule.

Furthermore, the present research indicates the most favorable target population for U-Bike Project is the *Preparation* stage, which contains those who have the most positive views and attitudes to maintain such new mode of transport afterwards. The *Contemplation* stage faced personal and physical barriers which declined their cycling frequency during the week. The most unfavorable population is in the *Precontemplative* stage, in fact, none representative of this group wanted to participate into the cycling experience, as well as they hold the most negative views towards the bicycle.

The main results of cycling experiment are summarised in the Fig. 14 below:

Fig. 14 - Cycling experience's main results



Color scale: green - maintenance stage; blue – action stage; yellow – preparation stage; orange – contemplation stage.

5
CONCLUSIONS

Researching the influence of bicycles provision in the promotion of sustainable mobility amongst students and staff who are automobiles users is valuable as a way to establish effective planning tools and measures to upgrade the overall quality of life on campus and increase the active commuting patterns. Thus, this dissertation explored, as an ex-ante evaluation, the academic community at the Faculty of Engineering at the University of Porto, within the sustainable mobility project U-Bike Portugal.

By investigating the current behaviour and perceptions towards cycling amongst the university population, this research found that the attitudes towards cycling become more positive with the increase of cycling frequency and if the person does not own a car for daily use. Furthermore, those who spent more time commuting by motorised modes and live in a quite far distance from the university have highlighted more negatives views of the journey than the positive ones. Certainly, as found in preceding researches, increasing trip length represented as a greater trip time an important and significant negative effect on the attractiveness of cycling (Hunt, 2007; Gatersleben, 2007).

As already found in previous studies, this research found a higher bicycle usage amongst man (North, 2012; Molina-García *et al*, 2015; Gatersleben, 2007), and those who live in a reasonable cycling commuting distance, within 30 minutes or 5 km (Molina-García *et al*., 2013). The bicycle usage is popular not only amongst the youngers (Shafizadeh, 1997) but also adults between 36 and 45 years old. Above such age gap, the use of private vehicles is considerably higher than the bicycle.

The level of bicycle ownership and environment awareness do not mean better attitudes towards cycling. In fact, a great share of respondents who owns a bicycle and agreed that cycling is a healthy mode of transportation and good for the environment, do not cycle for any purpose, neither use it for physical activities. Furthermore, the frequency of cycling was higher during weekends, holidays and for leisure activities. A great share of the community holds the vision that the bicycle is not suitable for commuting purposes.

The lack of cycling infrastructure conditions and the perceived danger play an important role in the cycling frequency, especially for non-cyclists and those who cycle longer distances as found in previous studies (Hu,2015; Fernández-Heredia *et al*, 2014; Fyhri, 2017; Molina-García *et al*, 2013; Dijkstra, 2000; Whannell, 2012; Handy 2011; Dill, 2009; Wang *et al*, 2014; Kaplan, 2015; Poinsatte, 1999; Gatersleben 2007; Heinen, 2010; Agarwal, 2012; Rietveld, 2004). In fact, even though the sustainable awareness is expressive amongst the university's constituents, a great share holds negatives views of their personal conditions and the current built environment, which decrease the likelihood of cycling in a daily schedule.

Furthermore, cycling in narrow routes, with irregular ground pavement (Stinson, 2003), the lack of connectivity and directness in the urban form (Aultman-Hall, 1997), as well as the unsafe parking spots in the city and in the university setting (Fernández-Heredia *et al*, 2014; Heinen, 2010; Agarwal, 2012) proved to be great deterrents to cycling in the city.

The environmental factors played some unexpected roles in the uptake of cycling. This investigation found the hilly topography in the city was not considered a great impediment to cycling, as found in other researches (Fernández-Heredia *et al*, 2014; Fyhri, 2017). Topography played a dual role into cycling level, on the one hand providing pleasure and speed through downhill routes. On the other hand, cycling on uphill routes can be uncomfortable and challenging, since it constrained speed and accessibility. The weather was also seen in a positive and negative way, with people cycling more frequently in sunny and warmer days, than during rainy and hot ones, as already stressed in the literature reviewed (Hu, 2015; Fernández-Heredia *et al*. 2014; Fyhri, 2017; Whannell, 2012; Swiers, 2017; Wang *et al*, 2014, Rybarcyk & Gakkagher, 2014; Heinen, 2010). Above all the environmental factors, the pollution in the areas with heavy traffic was the biggest impeditive to cycling in this research, especially for those who cycle longer distances.

The U-Bike targets the automobile users who live within higher distances to be travelled as the favorable group to receive the bicycle for commuting purposes. However, this research found a great share of the university population is car-orientated and do not have interest in swift their current transport mode towards bicycle, especially those who live more than 5 km away from the university. Thus, such group proved to be the most restrictive group to change mobility behavior. The large portion of those who cycle to the university often or every day have their origins within favorable accessibility conditions to travel to the university, which represents a distance between 2 to 3km on average. This research suggests such accessibility as the most favorable one regarding the target area, under U-Bike Project.

This dissertation found a potential share of the university community, which gather the favorable personal and physical conditions to uptake cycling in a daily schedule. However, each profile requires specific complementary measures otherwise, the expected modal shift may not suffice. Above all, respondents who are contemplating and prepared to cycle to the university claimed that the provision of better facilities and security would be the greatest incentives towards such modal swift.

The U-Bike Project may set the most effective instruments focusing on the needs of the population which will be covered by such measures, in order induce a take up and maintenance of cycling in the university context, supported by the monitoring and evaluation system.

By exploring the university community's needs and barriers to assess the favorable target population for a bike renting schemes as the U-Bike, this research found the most promising group is in the *Preparation* stage, which contains those who have the most positive views towards bicycle among the other groups and could keep such new mode of transport afterwards. They have valued the flexibility, speed, and enjoyment during the cycling trial. Such group usually live within favorable accessibility conditions – up to 4km - already has a promising bicycle frequency usage for leisure and free time activities. Furthermore, they want to start cycling for commuting purpose but hesitate due to physical barriers perceived and is the group with the lowest bicycle ownership in the sample. After the cycling experience, the barriers perceived dropped significantly, while for the contemplative participants remained steady.

This research revealed the most favorable condition for new cyclists keep such behavior is the provision of better bicycle facilities and security. Those who cycle to the university always or often will keep such mobility choice, and just an accident or bicycle robbery would stop them to cycle to the university. The secondary deterrents to cycling for the potential new cyclists are the bad weather, family or work schedule and, heavy road traffic, especially for those who will travel longer distances.

Even though, this research found the current city's built-environment is car-orientated and unfriendly towards cycling, the provision of the bicycle has the potential to increase self-awareness and better attitudes towards cycling. After experiencing the use of the bicycle for commuting purpose, more than half of the participants moved to a better stage in the BCS model. However, this research revealed the unattended bicycle access scheme is not determinant to create and maintain such new mobility pattern since barriers as the lack of security, heavy traffic and poor road conditions constrain the likelihood of potential new cyclists to keep such modal choice for commuting purposes.

5.1. RECOMMENDATIONS FOR THE U-BIKE PROJECT

Such findings give insight into the need for complementary measures, for each BCS group, to foster the increase of cycling frequency and support the users to overcome their perceived barriers.

This research recommends, for the restrictive stage – *Precontemplation* – campaigns, educational programs, and brochures to increase the sustainability awareness regarding their current impact on the local environment. In fact, there is a great share of people living in cycling and walking conditions and still use the car for commuting purposes. Such group may not understand that bicycle provide the flexibility and speed within distances up to 30 minutes. In fact, this research found the bicycle commuting time was shorter than the car, in congested roads and during rush hour. Thus, would be valuable for them to have information regarding time, fuel savings, routes options, as well as the healthy and sustainable benefits associated with cycling. Almost half of this group claimed that they would cycle to FEUP if they live closer. Thus the University could offer incentives to bring the student closer to the campus. A partnership between the University and the municipality could facilitate or provide financial aids for student accommodation access.

Based on the *Contemplation* and *Preparation* demand, the university could implement a Bike User Group or a Cyclist's forum in the University, which would be an important component for making the cyclists needs visible and relevant within local policies. In fact, those who start cycling need feedback, social support, and reinforcement of specific plans to ensure that they will keep such behavior. Furthermore, such society could carry a Bike Buddy Scheme to guide the new cyclists through the territory recognition, as well as providing information about better and secure routes. The university could offer a Bicycle Repair Service to provide quick and easy maintenance service in case of unexpected bicycle damage, as well as provide cycle security equipment such as helmets, lockers and light kits.

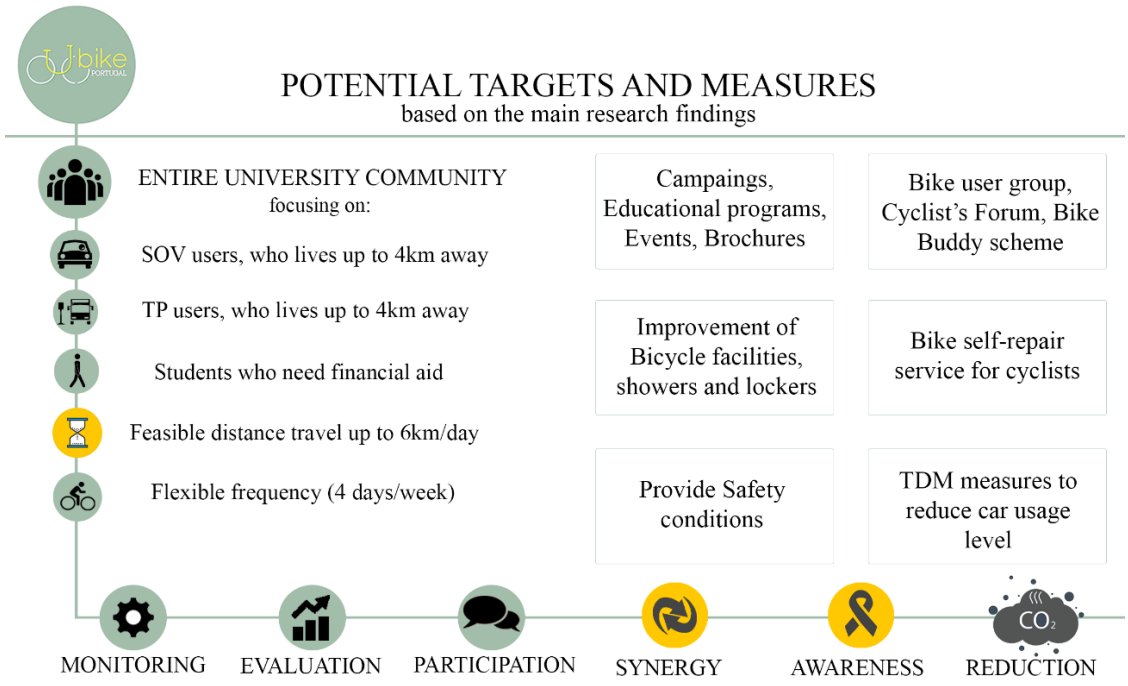
Keeping such mode choice feasible and pleasurable for the current cyclists – *Action* and *Maintenance* stages – requires better bicycle facilities and safety conditions, not only in the campus setting but also in the whole city. A great share of representatives has claimed that the current parking spots are unsafe and insufficient, with some volunteers reporting previous theft experiences in the campus. The University should improve its bicycle parking location and design. Regarding the campus cycle lanes, such infrastructure should be rebuilt, with comfortable and safe dimensions, throughout a partnership with the municipality to guarantee a safer circulation and feasible journey for cyclists.

The University could also set a package of TDM measures, such as parking restriction and pricing for those who live up to 3km away from the faculty and offer incentives for those who use public or active modes of transportation.

The implementation of such sustainable project has the potential to raise awareness towards cyclists needs, fostering the engagement of policymakers and stakeholders since the increase of cyclists will reflect not only within the university setting but also in the whole urban network.

Throughout the complementary measures recommended, the present project would encourage urban planners, stakeholders and community to rethink the city towards bicycle as an effective and flexible mode of transportation, as well as reinforce the communication channel between community, stakeholders and city planners. The Fig. 15 suggests the potential targets and complementary measures within U-Bike Project implementation.

Fig. 15 – Potential Targets and Measures based on the main research findings



6
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7
APPENDIX

7.1. SURVEY

De Bicicleta para a FEUP

Este Inquérito é componente integrante da Investigação de Mestrado que está a avaliar o comportamento da comunidade FEUP perante o uso da bicicleta. Seu contributo é de grande importância e será registrado de forma anónima e confidencial. Este inquérito levará cerca de 5 minutos a ser respondido. Agradecemos a sua contribuição para a referida pesquisa.

*Obrigatório

Percurso Casa - FEUP

1. Dentre as opções abaixo, qual o principal modo de transporte utilizado no percurso Casa-FEUP? *

Marcar apenas uma oval.

( )A pé
( )Autocarro
( )Automóvel (sozinho)
( )Automóvel (partilha)
( )Bicicleta
( )Comboio
( )Metro
( )Motociclo
( )Outra:

2. Qual a duração do percurso Casa-FEUP (em minutos)? _____*

3. Indique a Freguesia da sua morada: _____

4. Indique o nome da rua em que mora: _____*

5. Qual o seu horário de chegada habitual à FEUP? _____*

6. Qual o seu horário de saída habitual da FEUP? _____*

7. Numa escala de 1 a 5, o quão longa ou curta considera a sua viagem Casa-FEUP? * *Marcar apenas uma oval.*

1	2	3	4	5
( )	( )	( )	( )	( )

8. Indique o seu grau de concordância com as características apresentadas na deslocação Casa-FEUP: * *Marcar apenas uma oval por linha*

	Discordo Completamente	Discordo	Concordo	Concordo Completamente	NS/NR
Estressante	( )	( )	( )	( )	( )
Animada	( )	( )	( )	( )	( )
Entediante	( )	( )	( )	( )	( )
Relaxante	( )	( )	( )	( )	( )
Interessante	( )	( )	( )	( )	( )
Depressiva	( )	( )	( )	( )	( )

9. Qual a sua probabilidade em alterar o seu modo de transporte actual para os seguintes modos, no percurso Casa-FEUP?:* *Marcar apenas uma oval por linha*

	Improvável	Pouco Provável	Talvez	Provável	Muito Provável
A pé	( )	( )	( )	( )	( )
Autocarro	( )	( )	( )	( )	( )
Automóvel	( )	( )	( )	( )	( )
Automóvel (partilha)	( )	( )	( )	( )	( )
Bicicleta	( )	( )	( )	( )	( )
Comboio	( )	( )	( )	( )	( )
Metro	( )	( )	( )	( )	( )
Motociclo	( )	( )	( )	( )	( )

O uso da Bicicleta

Esta secção busca caracterizar a sua intenção e apreciação relativamente ao uso da bicicleta como meio de transporte.

10. Sabe andar de bicicleta? *

Se marcar a opção "não", salte para a pergunta de nº 14. Marcar apenas uma oval.

( )Sim

( )Não

11. Tem bicicleta à disposição para uso diário?

Marcar apenas uma oval.

( )Sim

( )Não

12. Em média, quantas vezes por mês utiliza a bicicleta? (caso não tenha bicicleta, imagine lhe seria fornecida uma).*Marcar apenas uma oval.*

( )Nunca

( )1 vez por mês

( )2 a 3 vezes por mês

( )1 vez por semana

( )2 a 3 vezes por semana

( )Diariamente (7 vezes por semana)

13. Com que frequência utiliza a bicicleta nas seguintes situações? (caso não tenha bicicleta, imagine lhe seria fornecida uma).*Marcar apenas uma oval por linha.*

	Nunca	Raramente	Ás vezes	Frequentemente	Sempre
Ir e voltar do trabalho/escola/faculdade	( )	( )	( )	( )	( )
Ir às compras (mercado)	( )	( )	( )	( )	( )
Ir às compras (diversas)	( )	( )	( )	( )	( )
Visitar amigos	( )	( )	( )	( )	( )
Ir ao ginásio / centro desportivo	( )	( )	( )	( )	( )
Lazer (sem destino específico)	( )	( )	( )	( )	( )
Feriados e fins de semana	( )	( )	( )	( )	( )

14. Quantas pessoas conhecidas (amigos, colegas e familiares) utilizam a bicicleta para ir ao trabalho e/ou faculdade? **Marcar apenas uma oval.*

( )Nenhuma

( )de 1 à 3 pessoas

( )de 4 à 10 pessoas

( )mais de 10 pessoas

15. Em que circunstâncias estaria disposto(a) em utilizar a bicicleta na deslocação Casa-FEUP? *

_____

_____

16. Por favor, indique em até que ponto concorda com as seguintes declarações sobre bicicletas e ciclovias: * *Marcar apenas uma oval por linha*

	Discordo Completamente	Discordo	Concordo	Concordo Completamente	NS/NR
Sinto-me em condições físicas para pedalar até a FEUP	( )	( )	( )	( )	( )
Sentir-me-ia desconfortável numa bicicleta	( )	( )	( )	( )	( )
Usar a bicicleta é bom para o meio ambiente	( )	( )	( )	( )	( )
Há balneários suficientes na FEUP para os ciclistas	( )	( )	( )	( )	( )
Eu gosto de andar de bicicleta	( )	( )	( )	( )	( )
Há bastante estacionamento de bicicletas na FEUP	( )	( )	( )	( )	( )
A maioria das pessoas que conheço nunca consideraria ir de bicicleta para o trabalho e/ou faculdade	( )	( )	( )	( )	( )

Perfil Socioeconômico

17. Género: **Marcar apenas uma oval.*

( )Masculino

( )Feminino

18. Faixa etária (idade): **Marcar apenas uma oval.*

( ) <18

( ) 18 - 20

( ) 21 - 25

( ) 26 - 35

( ) 36 - 45

( ) 46 - 55

( ) 56 - 65

( ) Acima de 65

19. Indique a vossa função na FEUP: **Marcar apenas uma oval.*

( ) Estudante: Licenciatura

( ) Estudante: Mestrado Integrado

( ) Estudante: Mestrado
( ) Estudante: Doutoramento
( ) Investigador / Bolseiro
( ) Docente
( ) Funcionário

Próximos passos: Pedalar para a Faculdade

Durante o mês de maio, nós gostaríamos de realizar um experimento prático consigo. O experimento consiste na análise do comportamento dos estudantes e funcionários perante ao uso da bicicleta, que deverá ser utilizada no percurso casa-faculdade durante o período de 1 semana.

Para este estudo, estamos a procura de:

1) Pessoas que utilizem a bicicleta para ir para a faculdade regularmente
2) Não-ciclistas que gostariam de utilizar a bicicleta para ir para a faculdade

20. Se tiver disponibilidade e interesse em participar do experimento, por favor, escreva o seu nome e contacto abaixo. Esta informação será utilizada apenas para fins académicos e não será repassada a outras pessoas. Entraremos em contato consigo em breve.

_____

_____

7.2. INTERVIEW – CYCLING EXPERIENCE

ESTUDO PRÁTICO

DE BICICLETA PARA FEUP

Objetivo: (1) compreender qual grupo, de acordo com o estágio de mudança de comportamento, seria o mais favorável como público alvo no âmbito do projeto *U-Bike*, que prevê o uso da bicicleta numa extensão de 10km, diariamente.

Medidas: (1) persuadir participantes a se mover para o estágio 5, e perceber as principais barreiras e potencialidades perante o uso da bicicleta observados por cada um no percurso CASA-FEUP. (2) realizar teste piloto, de 1 semana, com pelo menos uma pessoa representante de cada perfil.

Análise Qualitativa: (1) Entrevistas e (2) Diário de Viagem

ENTREVISTA

ENTREVISTA (a ser realizada nos dias 10/05 e 11/05)

1) Qual o seu modo de transporte usual para a faculdade?
2) Explique-nos o motivo da escolha do seu modo de transporte atual.
3) Qual o seu percurso habitual durante a deslocação CASA-FEUP?
4) Qual o seu percurso habitual durante a deslocação FEUP-CASA?
5) Explique-nos o vosso interesse em participar desse experimento.
6) Quais as suas expectativas com relação à essa experiência de utilizar a bicicleta para ir e voltar da faculdade todos os dias da semana?
7) Qual seria o aspeto mais agradável esperado nessa experiência?
8) E o aspeto mais desagradável?

Obs: Entregar Diário de Viagem

ENTREVISTA (a ser realizada nos dias 21/05 e 22/05)

1) Quais as suas apreciações finais com relação ao teste?
2) Consideraria manter o uso da bicicleta para ir e volta da faculdade rotineiramente?
3) Por qual motivos você continuaria a utilizar a bicicleta ou não, para ir e voltar da faculdade?
4) Qual foi o aspeto da experiência mais agradável?
5) Qual foi o aspeto da experiência mais desagradável?

Obs: Recolher Diário de Viagem preenchido

7.3. TRAVEL DIARY – CYCLING EXPERIENCE

DE BICICLETA DE CASA **PARA A FEUP** Data: __/__/____

Horário de chegada na FEUP: ……

1. Deslocou-se para a **FEUP** hoje?
    1. Sim 2. Não (saltar as restantes questões)

2. Qual o modo de transporte que utilizou no percurso? (por favor, circule o modo de transporte com o qual percorreu a maior distância)

    1. Minha própria bicicleta
    2. Bicicleta arrendada
    3. Autocarro
    4. Metro
    5. Automóvel
    6. Outro ...…….

3. Utilizou outros modos de transporte no percurso? Em caso afirmativo, descreva a sua jornada com mais detalhes:

……..……
……..……

4. Qual foi a duração do percurso para a **FEUP**?

…… minutos

5. Realizou a sua rota habitual no percurso **CASA-FEUP**? (percurso mencionado na entrevista)

    1. Sim 2. Não

6. Se optou por outro percurso, por favor, descreva brevemente a apreciação do novo percurso escolhido:

……..……
……

7. Em geral, o quão agradável avaliaria a sua jornada para a **FEUP** hoje?

1	**2**	**3**	**4**	**5**
Muito Agradável	Agradável	Pouco Agradável Desagradável	Desagradável	Muito Agradável

8. Qual foi a experiência **mais agradável** durante o seu percurso **CASA-FEUP**?

……..……
……

9. Qual foi a experiência **mais desagradável** durante o seu percurso **CASA-FEUP**?

……..……
……..……

DE BICICLETA DA FEUP **PARA CASA** Data: __/__/____

Horário de saída da FEUP: ……

1. Qual o modo de transporte que utilizou no percurso? (por favor, circule o modo de transporte com o qual percorreu a maior distância)

1. Minha própria bicicleta
2. Bicicleta arrendada
3. Autocarro
4. Metro
5. Automóvel
6. Outro ..……

2. Utilizou outros modos de transporte no percurso? Em caso afirmativo, descreva a sua jornada com mais detalhes:

……..……
……..……
……..……
……

3. Qual foi a duração do percurso para **CASA**?

…… minutos

4. Realizou a sua rota habitual no percurso **FEUP-CASA**? (percurso mencionado na entrevista)

1. Sim 2. Não

5. Se optou por outro percurso, por favor, descreva brevemente a apreciação do novo percurso escolhido:

……..……
……

6. Em geral, o quão agradável avaliaria a sua jornada para **CASA** hoje?

1	**2**	**3**	**4**	**5**
Muito Agradável	Agradável	Pouco Agradável	Desagradável	Muito Desagradável

7. Qual foi a experiência **mais agradável** durante o percurso **FEUP-CASA**?

……..……
……..……

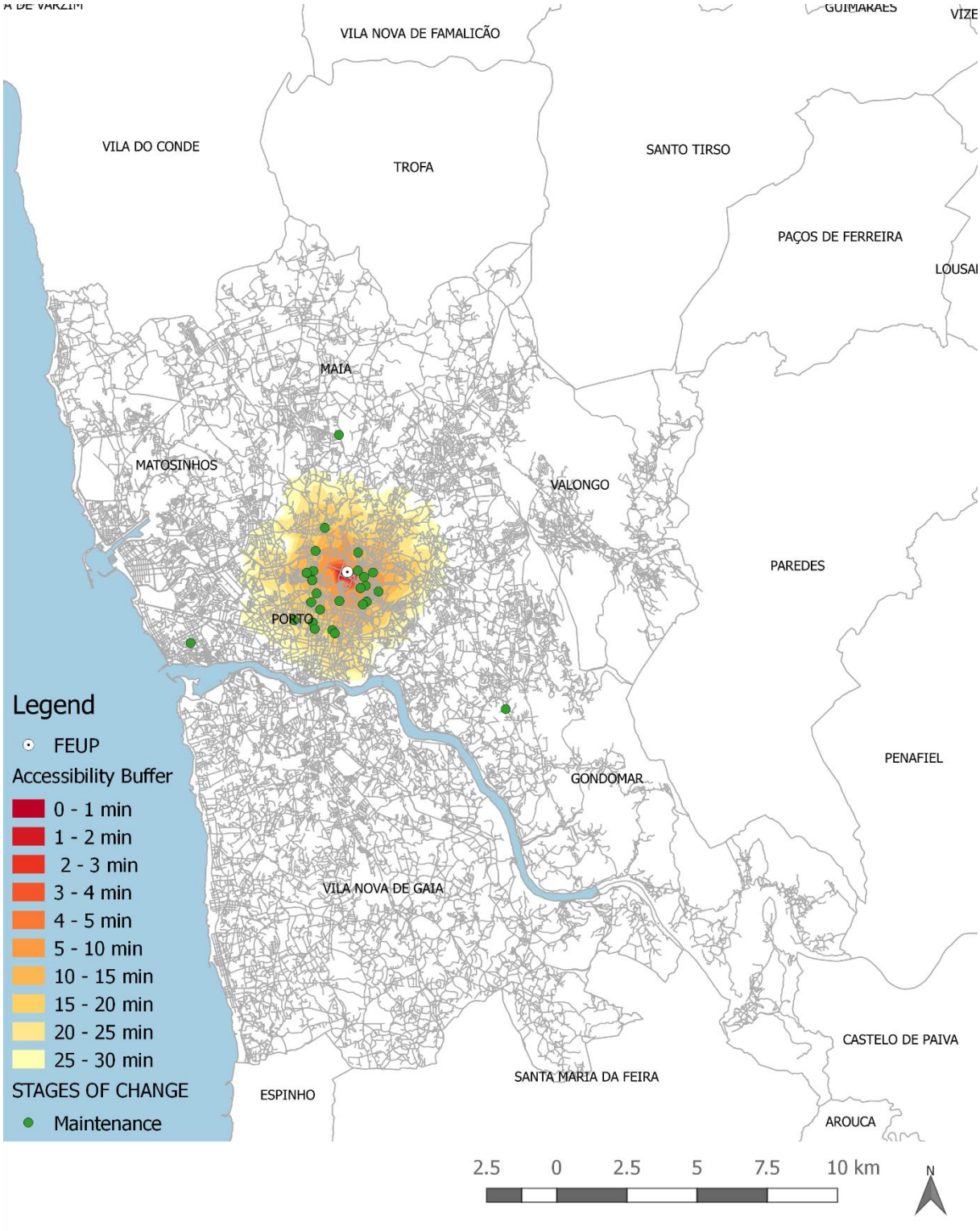
8. Qual foi a experiência **mais desagradável** durante o percurso **FEUP-CASA**?

……..……
……..……

7.4. SPATIAL MAPS BY EACH BCS GROUP

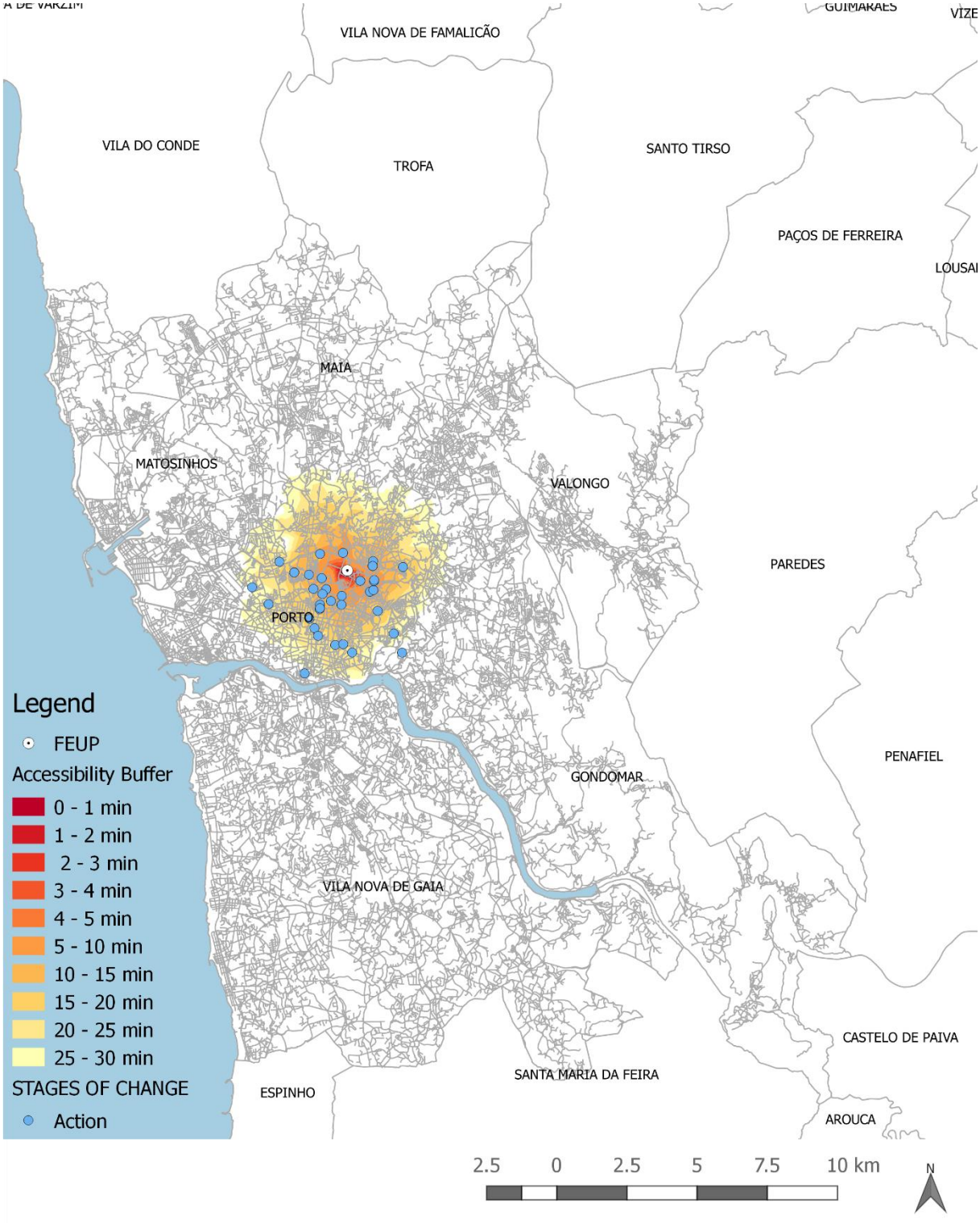
7.4.1. RESPONDENTS IN MAINTENANCE

Map 6 - Maintenance representatives' location



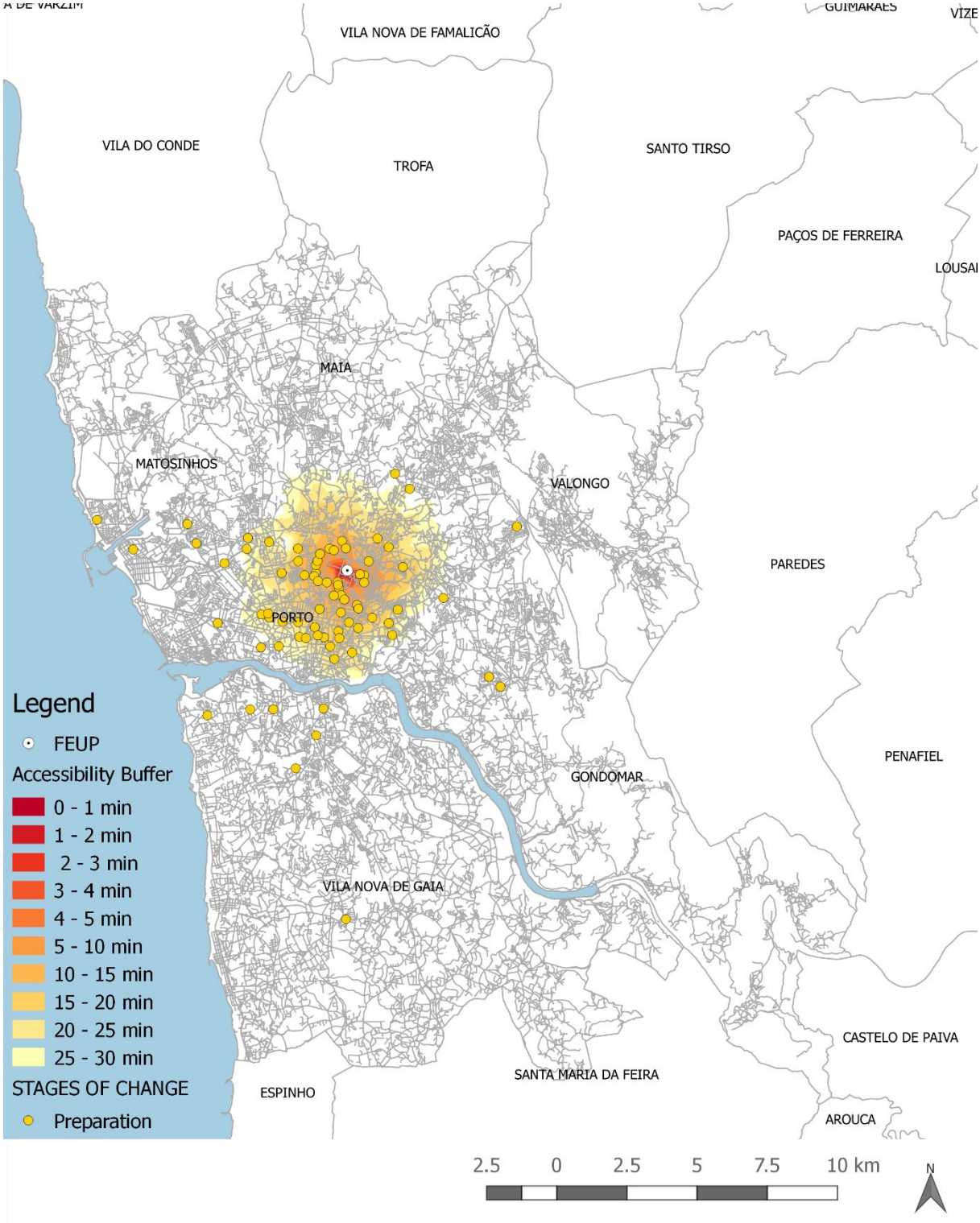
7.4.2. RESPONDENTS IN ACTION

Map 7 - Action representatives' location



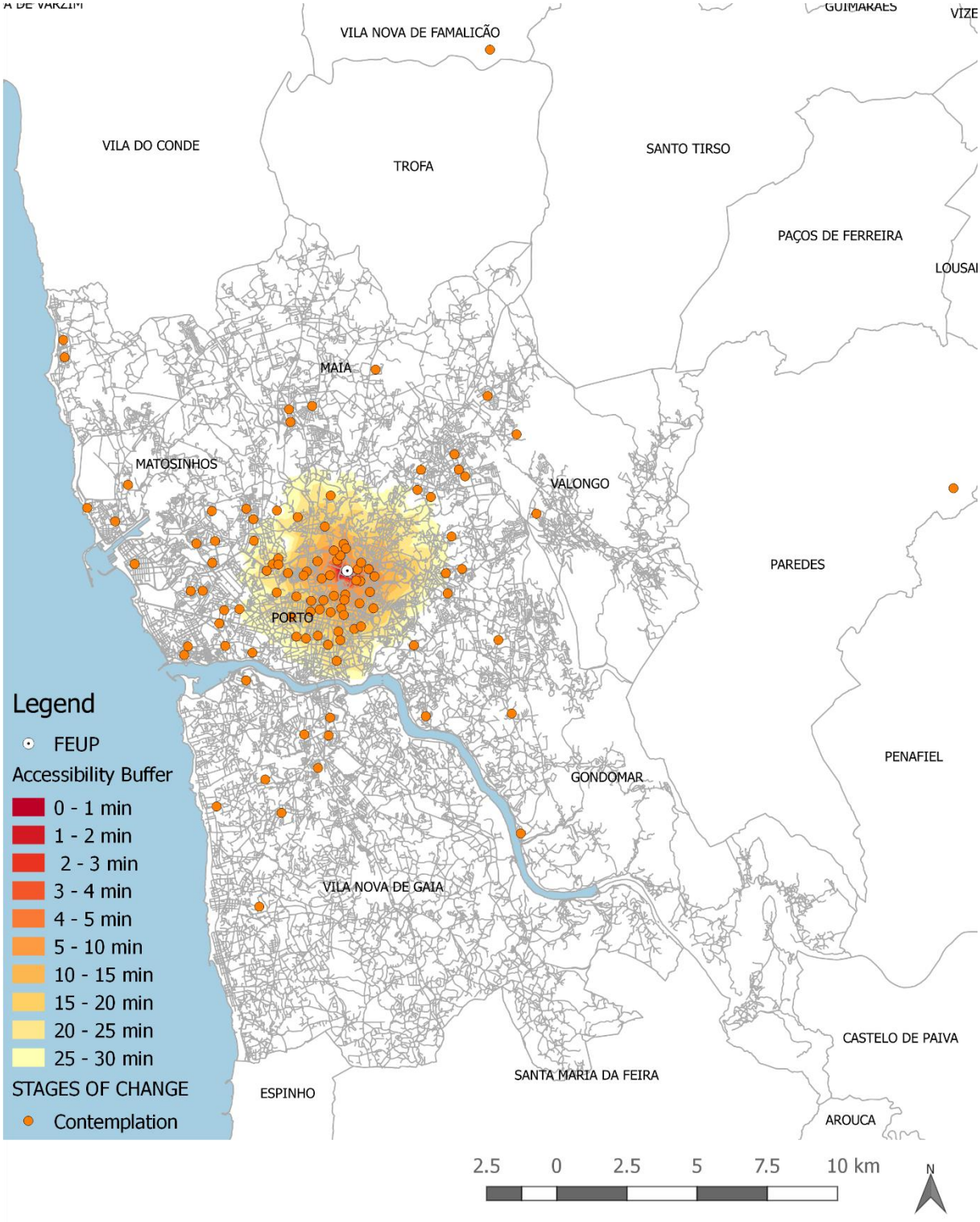
7.4.3. RESPONDENTS IN PREPARATION

Map 8 - Preparation representatives' location



7.4.4. RESPONDENTS IN CONTEMPLATION

Map 9 - Contemplation representatives' location



7.4.5. RESPONDENTS IN PRECONTEMPLATION

Map 10 - Precontemplation representatives' location